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ISTHMUS OF SUEZ CANAL.

THIRD SERIES.

ISTHMUS OF SUEZ SHIP CANAL.

REPORT AND PLAN

OF THE

International Scientific Commission;

WITH APPENDIX,

CONTAINING

THE LATEST OFFICIAL DOCUMENTS.

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SUEZ SHIP CANAL.

REPORT OF THE INTERNATIONAL COMMISSION.

The International Commission for the construction of the Canal across the Isthmus of Suez is composed of the following members:—

M. F. W. CONRAD, Chief Engineer of the Water-Staat, of the Hague.

Captain HARRIS, of the Honourable East India Company's Navy, London.

Captain JAURÈS, of the Imperial Marine, and Member of the Council of the Admiralty, of France.

M. LENTZE, Chief Engineer of the Works on the Vistula, of Berlin.

M. LIEUSSOU, Hydrographical Engineer to the Imperial Marine of France, of Paris.

Mr. J. R McCLEAN, Civil Engineer, of London.

Mr. CHARLES MANBY, Civil Engineer, of London.

M. MONTESINOS, Director of Public Works, of Madrid.

M. DE NEGRELLI, Inspector-General of Railways in the Austrian Empire, of Vienna.

M. PALEOCAPA, Minister of Public Works in the kingdom of Sardinia, of Turin.

M. RENAUD, Inspector General and Member of the Council for *Ponts et Chaussées*, of Paris.

Mr. J. M. RENDEL, Civil Engineer, of London.

M. RIGAULT DE GENOUILLY, Rear-Admiral of the Imperial Marine of France, of Paris.

President—M. F. W. CONRAD.

Secretaries—MM. LIEUSSOU and CHARLES MANBY.

REPORT—PART I.

SECTION I.

INTRODUCTORY REMARKS.

We have been invited by his Highness the Viceroy of Egypt, Mahommed Saïd, to give an opinion upon the design for the junction of the Red Sea and the Mediterranean, presented to him by his Engineers, in obedience to his commands, and upon the proposal of M. Ferdinand de Lesseps. In confiding to us the task of making a special examination of this preliminary work, and of preparing a definite plan, his Highness has not desired to circumscribe in any degree the extent of our researches on this great question in which the trade of the entire world is interested. Far from this; he has, on repeated occasions, caused it to be intimated to us, through M. Ferdinand de Lesseps, to whom the concession of the enterprise is granted, "that he set forth no kind of programme for the guidance of the International Commission charged with so important an inquiry; that, though the principal object was the examination of the design of his Engineers, he imposed no limits to the researches of science, and that, consequently, he invited us to extend our

investigation to all the tracks proposed within the last fifty years for establishing a communication between the Red Sea and the Mediterranean, in order that there should no longer remain any doubt as to the best means of uniting these two seas; in a word, that what he expected at our hands was the easiest and safest solution of this problem, and at the same time the most advantageous for Europe, for Egypt, and for the trade of the world in general."

The earliest care of the Commission, after having accepted this charge, was to repair to the locality, there to determine, by a personal examination, what were the obstacles, or the facilities presented by nature to the realization of the enterprise. Five of the members, viz., MM. Conrad, McClean, De Negrelli, Renaud, and Lieussou, repaired to Egypt in the month of November, 1855, and, after a minute investigation extending over a period of not less than two months and a half, they brought back with them, together with their own personal observations, the greater portion of the documents necessary to form the basis and furnish the proofs of a final decision. All such documents as they were not able to procure at the moment, they caused to be collected, according to their instructions, through special agents; and, after devoting a period of more than eight months to inquiries of every nature, the International Commission found themselves in a position to draw up such a project as had been required of them.

The question of a Canal across the Isthmus of Suez is one whose antiquity dates from the remotest ages. The object to be thus obtained has successively varied, however, with the requirements of each period. Originally, it was destined to form a connection between the valley of the Nile and the Red

Sea, in order to facilitate the intercourse between Egypt and Arabia; at the present day, the object proposed consists in effecting a communication between the Mediterranean and the Red Sea, in order to facilitate navigation between Europe and the Indian Ocean.

As a continuous intercourse was already maintained, between Arabia and Egypt, at a time when the elements of a transit traffic between the Mediterranean and the Red Sea had not yet sprung into existence, the idea of connecting the Valley of the Nile with the basin of the Red Sea must necessarily have preceded that of joining the two seas. The only notion which occupied the minds of the Pharaohs and the Kings of Persia was to procure an outlet for the produce of Egypt towards the Red Sea. With this confined object in view they opened a communication between the Nile and the Arabian Gulf, through an offset from the Pelusiac branch, the waters of which, in their natural course, poured themselves through the Wadee, till they reached Lake Timsah. But while thus supplying, in the simplest manner possible, the sole need asserting itself in their time, they were, in fact, opening a navigable channel between the two seas. So long as the largest vessels, in use at that time, could pass up the Nile, this solution of the problem of the junction of the Mediterranean and the Red Sea was the most suitable, since it satisfied at the same time the special trade of Egypt and the slight transit movement then existing.

It was not therefore in the nature of things, that, in order to avoid a circuitous route for vessels going from one sea to the other, the Pharaohs should have thought of undertaking a direct cutting across the Isthmus. For that epoch

it would have been a work of considerable magnitude; nor would it have dispensed with the necessity of a branch to the valley of the Nile. On the other hand, by restoring and enlarging the ancient canal of the Pharaohs, they fully satisfied, and at a much smaller cost, what the interests of commerce required in their time.

Under the Cæsars, the wants of trade were very nearly the same. But the diminution of the water in the Pelusiac branch, and the increased draught of vessels, having rendered the navigable channel between Bubastes and the Sea of Erythræa precarious, the Emperor Hadrian added to the depth of the canal, and insured a proper supply of water by taking it from the head of the Delta, at about the spot where Cairo now stands.

At the time of the Arab invasion, Amrou, the lieutenant of Omar, conceived the design, it is said, of connecting the two seas by a direct Canal from Suez to Pelusium. The waters of the Nile, brought from Cairo by the ancient canal of the Cæsars, were to have supplied this canal. But Omar opposed this project; moved by the fear of laying open to Christian vessels a path to Arabia. The fanaticism of the Caliphs closed Egypt herself to the trade of Europe. The Suez Canal had no other object then, as under the Pharaohs and the Persian kings, than specially to serve the trade of Egypt and Arabia, and its use was rendered subordinate to the state of political relations between the two countries. Omar at one time restored the canal of the Cæsars for the supply of provisions to Arabia, whilst one hundred and fifty years after him, El Mansour caused it to be filled up, in order to starve out Mecca and Medina.

The conquest of Egypt by the French revived the question of the Suez Canal, which had lain forgotten for ten centuries. M. Lepère, then Chief Engineer of the *Ponts et Chaussées*, after examining it by turns, with a view to Egyptian trade and to a grand transit channel for navigation, pointed out two methods of solution.

1. For the trade of Egypt, a canal of small section from Suez to Alexandria, through the central region of the Delta, fed by the waters of the Nile.

2. For transit navigation, a canal of large section from Suez to Pelusium, fed by the waters of the Red Sea.

This latter solution—(put forth rather as a desirable object to be attained than as a project the execution of which was possible)—it has never been possible, until now, seriously to take into consideration. We believe it to be the only method capable of satisfying the wants of the great ship traffic at present carried on between Europe and the Asiatic seas, where several European nations possess wealthy colonies, whose progress is daily becoming more rapid.

It is the prodigious development, during the last few centuries, and particularly in our own, of the commerce and the navy of all civilised nations, which has caused the want of this new and shorter path of communication to be so urgently felt. In ancient times no such need could exist, on account of the absence of any similar requirements. Trade and navigation until modern times carried on almost exclusively in the Mediterranean, had not attained sufficient importance to require increased facilities and a wider extension. Such scanty relations as were then maintained with

[illegible] worked [illegible] to their [illegible] and communication. [illegible] and Europe at that time [illegible] the Indian and Chinese [illegible] any of those immense establishments which have since been founded. [illegible] —had this idea been conceived at that epoch, the means would have been wanting to carry it into execution.

Since the discovery of the Cape of Good Hope, matters have greatly altered. But the path which this discovery opened up to navigation has for a long time been found insufficient for the requirements of the world, perilous as it may have been. It was not until the relations with Asia had gradually increased during a period of three centuries, and at a time when it had been giving any signs of diminution, that a further improvement became indispensable. England, the most deeply interested in these questions, since here are the richest and most extensive possessions in Asia, was the first to inaugurate this progress; and thanks to the introduction of steam, she has, within the last eighteen years, established through the Red Sea, and across the Isthmus of Suez, communications whereby travellers and despatches are transported in less than a month from the ports of India to those of the United Kingdom.

The canal which his Highness the Viceroy desires to construct, is therefore a work of universal utility.

This high destination of the new Canal clearly defines the spirit in which the works it requires should be conceived; and these considerations, however generally expressed, have appeared to us to represent the leading idea which should pervade our report. We shall not cease, therefore, to bear in mind throughout—that a grand Ship Canal,

affording an easy passage, always open and always secure, is what at the present stage of the commercial relations of the world is required by the civilized community.

SECTION II.

SUMMARY DESCRIPTION OF EGYPT AND THE ISTHMUS OF SUEZ.

The territory of Egypt is the portion of the basin of the Nile comprised between the cataracts and the sea. Hemmed in between two chains of mountains running almost parallel, and separating Lybia from the Red Sea, it forms above Cairo a very steep valley, two hundred leagues in length by from three to four in breadth, constituting Upper and Middle Egypt. Further on, it spreads out between the hills, towards the north-west and north-east, the two chains of mountains whose direction up to that point is from south to north, and forms between Cairo, Alexandria and Pelusium, an immense triangular plain 1,375 leagues, (3,437 miles) in surface, and constituting Lower Egypt.

The Nile had formerly seven branches, of which those at each extreme opened out towards Alexandria and towards Pelusium, and embraced the entire plain. It now bifurcates

above Cairo, forming two branches, which terminate at Rosetta and at Damietta, and thus divide Lower Egypt into three provinces—Behereh to the west, the Delta in the centre, and Cherkieh to the east. These three provinces are intersected by a multitude of canals forming ramifications from the two branches, and joining the series of lagoons along the sea-coast between Alexandria and Pelusium. These canals, excavated for the irrigation of land, are for the most part navigable during the season of the inundations; and, after having fertilized the soil, they supply facilities for transporting its produce. But the only canal of a really commercial character is the Mahmoudieh, which connects the Nile with the port of Alexandria.

The chain of mountains interposing to the East, between the valley of the Nile and the Red Sea, is a massive group with steep acclivities, rising to a great height to a spot on the direct line between Cairo and Suez; past which the mass suddenly sinks, and stretches to a point forming calcareous hills running to the north-east across Lake Timsah, and extending to Lake Menzaleh, in a series of plateaux of sand and gravel, constituting a part of the soil of the Isthmus.

This calcareous point may originally have been an advanced headland between the Mediterranean and the Red Sea. It still forms a distinct separation between the valley of the Nile, which forms the arable soil of Egypt, and the basin of the Isthmus of Suez, which is merely a desert. Regarded in this light this separation is hardly complete at present: for, at high floods, the waters of the Nile pour out into the Isthmus, over the northern region by Lake Menzaleh, and over the central portion by the valley of Wadee Toumilat, which forms a

slight hollow between the calcareous hills and the plateaux of sand and gravel. This natural outflow of the waters of the inundation marks the only two courses through which a canal from Alexandria to the Red Sea, across Egypt, could issue from the valley of the river into the Isthmus.

The waters of the Nile have over-spread the whole soil washed by them during the high floods with a layer of mud-sediment, the thickness of which is generally found to diminish in proportion to the distance from the stream. This surface deposit, which forms the tillage land of Egypt, rests upon a thick bed of sea-sand, still impregnated with salt.

The bed of the Nile, considered in the light of a vast section across the soil, exhibits, throughout, this division of the subsoil into two distinct layers. The line of demarcation forms a plain slightly inclining towards the sea, and nearly coinciding with the water-line at low-level. The infiltration of the waters into the sea sand, maintains a permanent moisture in the subsoil, which rising up through the bed of mould, covers the surface with a saline efflorescence. The tendency of the saline particles in the subsoil to make their way upwards, is increased in summer by the great heats and the pressure of the waters of the river above the low-water mark. This would inflict sterility upon the soil were it not annually washed over by the fresh water of the Nile. The irrigation of the soil therefore is in Egypt a primary condition of all husbandry. Hence the necessity for the multitude of canals which intersect Lower Egypt in every direction, and bear to every part of it, water—the source of vegetation and of life.

These canals serve both for inundating the land and for draining it after it has been submerged. To cut off the supply of these canals from the waters of the stream, or to intercept their outflow into the sea, are two equally sure means of rendering all cultivation in Lower Egypt an impossibility.

The canals cut through the stratum of vegetable soil, to take advantage of the inundation, are easily maintained. But those excavated in the stratum of sand, for the purpose of irrigation during the low levels, incessantly receive quantities of sand, carried in by the water during the process of infiltration, and they are even more rapidly choked up at the feeding point on the stream. A canal eight mètres (26 feet) in depth, would necessarily reach this stratum of sand, and the task of constructing and keeping it open would be one of serious difficulty.

From the cataracts to the sea a distance of 300 leagues, the Nile does not receive a single tributary; it presents from that point one uniform breadth, of, on an average, 1,200 mètres (1,312 yards) in Upper and Middle Egypt, and 600 mètres (656 yards) in Lower Egypt, where it is divided into two branches. It flows calmly and from South to North, across a level plain which is covered with its alluvium and slightly inclines towards the sea. The general inclination of this plain is one mètre per kilomètre (1 in 1,000), from the cataracts to Cairo, and 0.50, only one-half, from Cairo to the Mediterranean.

The Nile swells and subsides slowly and regularly—progressively rising through the months of June and September, its waters gradually sink down again from October to May. The height of the flood, which naturally decreases on

descending the stream, varies in different years, but keeping within a limited range. The lowest flood is about two-thirds of the highest.

This species of annual tide to which the stream is subject, periodically alters the condition of its navigation, a summary of which as regards Cairo is contained in the subjoined table:—

	Level above the Mediterranean.	Velocity at the Surface.	Quantity flowing per hour.
Minimum conditions at low water	14 m. — 0.00. (45 ft. 11 in.)	0 m. 50 (1 ft. 7.68 in.)	50,000,000 cub. mèt. (65,401,050 cub. yds.)
Maximum at high floods ...	14 m. — 8.00. (45 ft. 11 in. — 26 ft. 3 in.)	1 m. 50. (4 ft. 11.05 in.)	800,000,000 cub. mèt. (1,046,416,800 cub. yds.)

The waters of the Nile are always turbid, but principally so during the floods; they contain on an average 0.004 of mud. A portion of this mud remains upon the land inundated, and raises the level of the soil, but a large portion is carried down to the sea. The stream, moreover, drives along the bottom of its bed the sand swept into it by the winds, as well as that detached from its banks by the action of the current. The sand, by which numerous banks are formed along the course of the Upper Nile, is arrested in its progress at a considerable distance from the sea, so that at about 12 miles from the mouths of the river the soil forming its bed presents but slight traces of sand, which appears to be lost in the mass of muddy sediment, or alluvial deposit.

The Rosetta and Damietta branches are barred by banks of sand variable in magnitude, and covered with scarcely more than from 1 to 2 mètres (3 to 6 ft.) of water at low ebb, and from 2 to 3 (6 to 19 ft.) during floods.

These data as to the configuration and nature of the soil of Lower Egypt, and as to the condition of the Nile at various periods, were indispensable, in order to appreciate the relative value of the several tracks we were called upon to examine. We have now to convey a general notion of the Isthmus of Suez.

Without entering into geological details, which will be more suitably introduced elsewhere, it is requisite, however, that we should give a summary description of the entire Isthmus. Taking a straight line from the extremity of the Arabian Gulf to the Mediterranean, this tongue of land is 113 kilomètres (70 miles) in length. Suez is situated 29° 58′ 37″ north latitude; Tineh, the ancient Pelusium, being 31° 3′ 37″. The difference of latitude therefore is only 1° 5′.

The topographical chart in connexion with this Report will suffice to show at one glance the configuration of the Isthmus. Between the Red Sea and the Persian Gulf, running from South to North, there is a depression in the soil very distinctly marked, especially in crossing from the Bitter Lakes to Lake Timsah. Along the course of this depression there are indeed several undulations between the Bitter Lakes and Lake Timsah, and further on between Lake Timsah and Lake Menzaleh. But excepting two tracts of land rising to 12 or 15 mètres (39 to 49 ft.) in height, and of very limited extent, at the points above mentioned, there is a sort of *thalweg* or nearly horizontal course across the entire breadth of the Isthmus.

Towards the middle of this depression, that is to say, about on a line with Lake Timsah, there is another depression

nearly perpendicular to the first, and stretching from the centre of the Isthmus as far as the alluvial lands of the Delta. This second depression, less distinctly marked than the first, runs from West to East. This is what is called the Ouadee Toumilat, the ancient Land of Goshen, where the Hebrews settled under the conduct of Jacob, when Joseph called them thither, and whence they departed under the conduct of Moses, about seventeen centuries before the Christian era.

It follows, from this outward configuration of the Isthmus, that at the first glance the direction of the Canal between the two seas would appear to be traced out by the hand of Nature herself. In the second place, the other depression extending from Timsah to Belber, the ancient Bubastes, can be made to connect with equal facility the inland navigation of Egypt with the maritime navigation passing along her frontier. When the rise of the Nile is rather high, the Ouadee Toumilat becomes flooded with the waters of the stream, which reach Lake Timsah, and perhaps in former times found their way as far even as the Bitter Lakes, winding round the tract of land which divides the two. Those of our colleagues who proceeded to Egypt found the muddy sediment of the Nile in the swamps of Lake Timsah, similar to that which covers the plains of Lower Egypt and the hollow of the Nile valley.

Considered from this point of view, the solution of the problem appears very simple, and if anything is calculated to excite astonishment, it is that, in the presence of indications so distinct and so strikingly apparent to all who visit these localities, pains should have been taken to seek a more complex solution before decidedly ascertaining the impossibility of the one in question.

SECTION III.

THE INDIRECT TRACK.

Several motives appear to have deterred the majority of Engineers who have turned their attention to the subject in question from entertaining the idea of a direct track. These motives are the influence of tradition, which referred to little else than attempts to connect the Nile with the Red Sea; an imperfect acquaintance with the localities, favouring the supposition that the Bay of Pelusium was absolutely impracticable; and lastly a misconception of the true interests of Egypt, which country it was proposed to endow with a grand canal of inland navigation, overlooking that such a canal would be productive of more harm than benefit.

These motives, to which may be added certain political considerations into which it forms no part of our duty to inquire, induced the proposition of the three indirect tracks successively proposed since the beginning of the century, by M. Lepère, a Member of the Institute of Egypt, and Chief Engineer of the *Ponts et Chaussées* of France; by M. Paulin Talabot, Chief Engineer of the same corps; and by MM. Alexis and Emile Barrault. These three tracks traverse Egypt

and terminate at Alexandria, passing respectively through the centre, the apex, and the base of the Delta. Our task is to examine and judge them according to their several merits, from the point of view assigned for us, viz., the demand for a navigable Ship Canal, always free and always open.

M. LEPÈRE'S SCHEME.

M. J. M. Lepère was one of the members of the expedition to Egypt in 1798. He resided in the country more than two years, and was enabled personally to examine the elements of the problem, a solution for which he proposed to find. He had personally superintended all the levelling operations, and it was not till after four years of study that, on the 24th of August, 1803, he presented his memoir to the First Consul. This elaborate and conscientious production is entitled, *Mémoire sur la communication de la mer des Indes, à la Méditerranée, par la mer Rouge et l' Isthme de Suez.* (Memoir on the communication between the Indian Ocean and the Mediterranean by the Red Sea and the Isthmus of Suez.) It extends to no less than 168 pages in folio, and appeared in 1808, in the great work on Egypt, which forms one of the most glorious and substantial results of the French expedition. In accordance with the instructions of General Bonaparte, who had requested him to undertake this task, and who had been the first, before any of the escort who accompanied him, to discover the vestiges of the ancient canal in the desert north of Suez, M. Lepère directed his attention almost exclusively to the means of restoring the ancient canal.

The third section of his Memoir is especially devoted to a description of the canal in the restored form proposed by him. This canal was composed of three principal sections. The first, which differed little from the Canal of the Pharaohs, as M. Lepère stated, adducing the authority of the ancient writers, extended from the Red Sea to the Nile; commencing at Suez it passed through the Bitter Lakes, struck into the Wadee Toumilat, and opened out into the branch from Damietta to Bubastes. The second section availed itself of the branches of the Nile and its canals. Lastly, the third section was composed of the ancient canal of Alexandria, restored, and following almost exactly the direction subsequently traced out for the Mahmoudieh Canal.

In the first part of the canal there were at least four locks, which were to be of sufficient width and depth to receive, during the periods of high flood, sea-going vessels, drawing from 12 to 15 feet of water. The total cost was estimated by M. Lepère, though without pretending to determine it with any great accuracy, at the sum of thirty millions of francs, or £1,200,000. The time he required was five years for completing this labour, which he reckoned on abridging as much as possible by availing himself of still extant remains of the ancient works.

But while proposing this indirect track which, in his eyes, promised most advantage to Egypt, M. Lepère has made frequent mention of the direct cutting across the Isthmus between Suez and Pelusium, and regrets that he is unable to adopt this more simple solution of the problem, instead of the opposite mode, to which he gives his assent. Two motives appear to weigh with him. In the first place, he fears it would be impossible to excavate and

maintain at a sufficient depth, the channel from Suez to the deep bottom of the roadstead. In the second place, he cannot discover any spot along the coast at Pelusium where a commodious harbour could be formed, such as it was, nevertheless, indispensable to establish. He is apprehensive also of the silting which the winds from the North-West might produce, and these considerations determine his rejection of the direct track. But for these fears he would readily have proposed this track, which possessed the great advantage, to him, of constantly offering a navigable channel, independent of the Nile. In the opinion of M. Lepère it would have formed an excellent adjunct to the indirect track, and vessels of heavy tonnage might have sailed through this canal, while the smaller merchant-craft would have taken the other route. Although perfectly perceiving that the direct canal would shorten the course of navigation to India, M. Lepère is little impressed with the importance of this consideration; nor does he rightly understand the question of costs in this second canal, as may be inferred from the estimates laid down for the entire works.

M. PAULIN TALABOT'S SCHEME.

The scheme proposed by M. P. Talabot, and originally published in 1847, was a second time brought forward in 1855, in a justly esteemed literary periodical, the *Revue des Deux Mondes*, where it appeared in the number for the 1st of May, about two months after the publication of the project of the Engineers of his Highness the Viceroy. As

this second publication of M. P. Talabot is more complete than the first, our remarks will exclusively refer to it.

The canal is proposed to start from Suez; to follow the Ouadee Toumilat, and proceed to within a short distance of Cairo, to cross over the Nile above the barrage of Saïdieh, without making use of the stream itself; thence to take the direction of Alexandria, where it would terminate in the old harbour. The length would be about 250 miles, be 328 feet broad, and 26 feet deep, and it would be fed from the Nile.

In this scheme the principal difficulty lies in crossing such a stream as the Nile, which is not less than five furlongs in breadth. This is an obstacle of the most serious description; and to overcome it, M. P. Talabot leaves us a choice between two methods, which he details, without precisely deciding in favour of either. These are, on the one hand, to take the canal through the river itself, and on the other to have recourse to the expedient of an aqueduct. We will examine in turn both these methods, each of which is open to numerous objections.

Having clearly discerned the general scope of the problem, and feeling, as every one must feel, that the canal which Egypt requires in the present day is one that will admit the trade of the whole world, M. P. Talabot has given the necessary dimensions for the reception of the largest vessels. Thus the notion of bringing the canal through the stream itself, supposes that a depth of 26 feet of water can be maintained in the bed of the Nile by means of the barrage of Saïdieh.

Here, however, three difficulties occur. First, under no circumstances can the bed of the river be permanently sunk below the aprons, against which, at low ebb, there is only a depth of $1^{m}.80$ (or 5 ft. $10\frac{3}{4}$ in.) of water. It would, therefore, be requisite to raise the level of the water by 6.20 mètres, (or 20 feet). But the barrage was constructed on the calculation of a pressure of 4.50 mètres (14 ft. 10 in). Would it be prudent to lay on an additional pressure of 5ft. 6in. ? We consider that it would not.

In the second place, admitting that the attempt should be made, and, rash as it would be, that it should succeed, the result would be, that the pressure of water, at a height of 6.20 mètres (20 feet) above the low-water mark, (a level higher than that of the cultivated lands on the borders of the Nile,) would, in summer, cause infiltration upwards through the soil. Now, the effects of such an infiltration are familiar to all who have lived in Egypt; and it is a well known fact that, ere long, it would condemn the soil to sterility by covering it with a saline efflorescence. The canal, therefore, in this respect at least, would produce an effect diametrically opposite to that which was proposed, since it would diminish, instead of augment, the agricultural riches of the country.

In the third place, the sand brought down by the Nile would have an unavoidable tendency to form deposits above the barrage, where the velocity, except during the period of floods, would be less than in any other part of the stream. There would be no other way of counteracting this tendency of the bottom to shoal than having recourse to dredgers. But without taking into account the obstruction this would cause to navigation, there seems little ground for hoping

that the regular working of these machines, acting against the body of sand swept down, varying in quantity according to the conditions of the river, could maintain the bottom of the bed permanently on an equal level with the bottom of the canal. The difficulty in this respect would be caused by the difference in form of the bed of the Nile, in that portion crossed by the canal, from the ordinary section elsewhere.

Again it may be objected, that the crossing of the stream by vessels of large dimensions could not be effected without difficulty at the period of floods, when the velocity of the current is 1.50 mètres (4 ft. 11 in.) per second.

It should not be forgotten, moreover, that the barrage of the Nile is not yet completed. The work is one purely of local utility, and the necessities of the country, of which the Government of Egypt is the sole judge, will determine the moment when this great work is to be definitively applied to its destined purpose. It would be far from prudent, therefore, to render dependent on the completion of this undertaking, which yet may be delayed some time, the details of a project which it is intended to carry at once, or very shortly, into execution.

We are bound to observe, however, that, foreseeing the serious disadvantages attending the plan of crossing the stream itself, M. P. Talabot frankly confesses that "the keeping up such a depth is accompanied with difficulties which have never hitherto been surmounted, or attempted to be coped with." The author of this project seems to think, therefore, with us, that the method of crossing on a level with the river is an impracticable one, and hence it is allowable to

suppose that he inclines rather to his second idea, which is an aqueduct thrown over the Nile at the spot indicated for the crossing of the river, at no great distance from Cairo.

We must, however, come to a proper understanding as to what an aqueduct under these conditions would really be.

In the first place, to allow a sufficient passage for the stream, this aqueduct would require to be at the very least, 1 kilomètre (five-eighths of a mile) in length. Its breadth would have to be about 38 mètres, (120 ft.), to allow of two vessels passing abreast without collision. M. Talabot fixes its height at 12 mètres (40 ft.) above the level of high floods. But this is not sufficient. It would be necessary, in the first place, to give the aqueduct this height of 12 mètres (40 ft.) at least above the level of high floods to allow the river boats to pass with their masts, to say nothing of their yards, which they could always lower. This makes, of itself, from 18 to 20 mètres (58 to 65 ft) above the low-water level. To this must be added the 8 mètres (26 ft.) of water the canal itself would have, and 2 mètres (6½ ft.) for the thickness of the arches. This gives, altogether, a height of from 22 to 23 mètres (72 to 75½ ft.) above the Nile when swollen by the periodical flood and full, or at about 30 mètres (96 ft.) above the level of low water. Lastly, the level of the floods being already 19 mètres (62 ft.) above the level of the two seas, the aqueduct will be, at the very least, 40 mètres (130 feet) above the Red Sea and the Mediterranean.

Let us suppose, with M. Talabot, that a fall of 3 mètres (9 ft. 8 in.) be given to the locks ; fourteen, or fifteen locks will then be required on each side of the canal. This number could only be lessened at the expense of the quantity of water required to meet the exigencies of navigation.

If, in order to lower the level of the central basin, a canal be established, as in other respects would be preferable, running laterally to the Nile, for the use of boats navigating the river, the number of locks might be reduced to ten on each ascent. But, on the other hand, the expense will have to be incurred of establishing the locks necessary for the navigation of the canal, setting aside the expenses for their supply.

Whichever be the system adopted, whether with, or without a lateral canal, an aqueduct five furlongs in length, and not less than ninety-four feet in breadth, provided at each extremity with several locks, packed one against the other for the purpose of raising to a great height, would constitute an extremely expensive assemblage of works. But this would, perhaps, be the least disadvantage consequent on the adoption of the aqueduct. The grouping of a number of locks at each end of the work would incontestably occasion delay in the movement of the shipping, and, probably within a no distant future, the canal might prove inadequate.

The feeding of the canal, (M.Talabot himself acknowledges it,) constitutes the principal difficulty in his scheme. As a mode of providing for it, he suggests the employment of steam engines, by means of which the water from the Joseph canal, which runs at the foot of the Lybian chain, should be raised into a reservoir, which he would establish in one of the gorges of this chain, and bring into communication with the central basin. He estimates the volume of water to be daily used for the passage of vessels over the aqueduct at 300,000 cubic mètres (3,588,100 cubic yards), and sets down from 600 to 800 horses as the power of the engines required to raise this volume of water to a height which he estimates at 12 mètres (39 feet).

This mode of supply is inadmissible, the Joseph canal being dry during a portion of the year. The water must of necessity be taken directly from the Nile, in which case it is impossible to think of establishing a reservoir in the Lybian chain, which, at that part, lies at a distance of twelve miles from the stream. All that could be done would be to make the central basin perform the office of a reservoir, by raising its level from 2 to 2·50 mèt. (six and a-half to eight feet), and in making the engines of sufficient power to supply the canal in the exact measure of the amount consumed, calculated on the most active degree of traffic probable.

In this case, calculating on a maximum traffic of four vessels per hour, and an elevation of 16 mètres (52 ft.) for the level to which the water is to be raised, we find that it would be necessary to employ engines whose collective power would amount to 4,000 horses. The expense of maintaining such engines is equivalent to the whole being an impossibility.

The amount of sediment which would be annually deposited in the canal is estimated by M. Talabot at 87,310 feet (73,000 cubic yards.) To arrive at this result, he supposes that the mean proportion of sediment held in suspension in the water of the Nile is the same as that ascertained in the case of the Rhine, namely 0·0004 of the volume of water. But, in fact, the quantity is much more considerable, being not less than 0·008 during the rise, and 0·002 at low water. If we take 0·004 as the mean proportion, we find the amount of deposit which would be formed in the 243 miles of canal would be annually 2,738,660 cubic mètres, the extraction of which would not cost less than £80,000, and would require the existence of from twenty-five to thirty dredges permanently at work in the canal.

But these are not the sole objections to which the scheme of M. Talabot is liable. His canal would, for a portion of its course, be cut through the alluvial lands of the valley of the Nile. These lands lie throughout upon a bed of very fine sand, at about the level of low-water mark in the river. The excavation of a canal in this sand would present great difficulties. If the work were done by manual labour and digging, the sand swept along by the waters would have a constant tendency to fill up the excavations. This would naturally lead to the employment of dredging boats, and thence would arise a notable increase in the cost of the earthworks.

As happens with all canals on which locks are used, it would be impossible to avoid delays, and the injury therefrom to the interests of commerce would be enormous.

The haulage could only be conveniently done by means of horses, as, from the numerous locks, towing by steamers would be out of the question. Now, the expense of haulage by horse power at the highest rate of speed cannot be estimated at less than (3 centimes per kilometre), 0.48d. per ton per mile. This would amount to about 10s. for the whole journey from Suez to Alexandria. Such a tax would render the enterprise completely unprofitable.

Finally, as the canal passes through the heart of Egypt, and divides it into two large portions, isolating one from the other, whatever be the track followed beyond the Nile it must cut through all the canals for irrigation and flooding which intersect the rich provinces of Cherkieh and Behereh, bringing to all parts of the country the water which is indispensable to every species of tillage. It affects, therefore, most deeply, the very complex hydraulic system on which is

based the agricultural wealth of a great portion of Egypt. In consequence of this, it would impose on the Company holding the concession, the obligation of remodelling every inch of this hydraulic system, which ought however to preserve entire and free the power of extension and transposition at present proper to it. Independently of the serious disturbances of every description which it is easy to anticipate from such an enormous change, this would become an endless source of litigation either with the Government, the vigilant custodian of the canals, or with individuals whose property might be interfered with. In any case it would be imposing a very heavy burden on the Company, and one which the partisans of this track seem not to have sufficiently considered.

We have now, on the subject of the scheme at present before us, to offer a few observations relative to the outlet of the canal into the Mediterranean.

The old harbour of Alexandria, into which the canal would fall, is a spacious and secure roadstead, although exposed to the winds from the W.N.W. during two-thirds of the year. But the entrance and departure from the harbour — always slow and difficult, even in ordinary weather—become impossible, when the sea runs high, for vessels drawing more than 19½ feet of water. To make the old harbour easy of access in all weathers, it would be necessary to widen the principal channel, by levelling to a depth of 32 feet the dangerous breakers which hem it in. The canal could only open into it between the outward wall of the city and the railway station. But this region is itself a rocky one, and it is swept by the gales from the N.W. The mouth of the canal would not be accessible to large

vessels, except under the condition of being carried out into the sea between jetties as far as 9 mètres (5 fathoms) soundings, at a distance of 400 mètres (437 yards) from the shore.

The channel would have to be excavated out of the hard rock, a labour which would be attended with no little difficulty.

Moreover, as the channel would open out upon a hidden bank of quicksands, which, whenever it blows a storm from the N. W. or N. E., are driven backward and forward, it would be liable to become obstructed by this sand, and could only be kept clear by the use of dredging boats.

The old harbour of Alexandria is, thus, far from offering an economical and easy outlet to the canal.

The track, therefore, of this proposed canal from Alexandria to Suez is one which cannot, in an engineering point of view, be entertained.

M. P. Talabot appears himself to have been fully alive to a portion of the difficulties we have just pointed out; and he has stated that he would have preferred bringing the canal out at Pelusium rather than at Alexandria, had not the establishment of a port in the Gulf of Pelusium appeared to be impossible. M. P. Talabot does not allege any very full or precise reasons for adopting this opinion, which he has borrowed from M. Lepère; and M. Lepère had himself assumed it without any further examination from the bad reputation acquired in modern times, by the bay of Pelusium, so much resorted to by the ancients.

M. Talabot may, therefore, be considered to have decided in favour of an indirect track only because he was unacquainted with the real state of things as regards the bay of Pelusium.

There are also certain objections of a political nature which would not fail to alarm the prudence of the Egyptian Government. But the discussion of these objections, in themselves decisive against the scheme, does not lie within the sphere of our investigations, and, as far as we are concerned, this mere allusion to them will suffice.

In conjunction with these purely technical questions, M. Talabot discusses another, upon which we are happy to declare ourselves entirely in accordance with him. He has, in his Memoir, laid down the fact as resulting from the surveys of 1847, that the two seas are level. It will be seen hereafter that this fact, published by him for the first time, has been subsequently confirmed on several occasions. It must henceforth rank as an acknowledged scientific conclusion.

SCHEME OF MM. BARRAULT.

The track proposed by MM. Alexis and Émile Barrault, in an article which appeared on the 1st of January, 1856, in the *Revue des Deux Mondes*, (the same periodical in

which, a year before, M. Talabot had published his scheme,) follows an intermediate course between the direct track from Suez to Pelusium, and that which passes through Cairo to Alexandria. Proceeding at first from Suez to Lake Menzaleh in a direct line, from S.E. to N.W., it keeps within it until quite close to the sea when it turns in a parallel direction for a distance of more than 100 miles, and falls into the new harbour at Alexandria. Thus it will be seen that MM. Barrault transfer the crossing of the Nile from the region of Upper to that of Lower Egypt. Their canal crosses the stream at two principal branches of Rosetta and Damietta. The problem is thus shifted from the apex of the Delta to its base, and, in effecting this transposition, MM. Barrault hoped to escape the charge brought against M. Talabot's project of interfering with the hydraulic conditions of the Lower Nile and its branches.

Although the scheme advanced by MM. Barrault, who have never explored the locality, shows no signs of any deep, or earnest study, we consider it our duty to give it a summary examination, that we may avoid the reproach of having passed over in neglect any one of the proposed solutions of the problem now before us. First, we will describe the general system on which this track is based.

It is divided into three reaches. One extending from Suez to the Damietta branch; the second from Damietta to Rosetta; and, finally, the third fiom Rosetta to Alexandria. The water in these three reaches is for the most part maintained at the same level, namely, about three feet and a quarter above the level of the Mediterranean. The intention is to eed this canal with water drawn from the Nile by a canal

extending from Bubastes to Lake Timsah, through the valley of the Ouadee, and with water drawn directly from the two principal branches of the Nile, accumulated by means of dams.

The minimum depth of water in the canal would be about 8 m. 50 (28 feet.)

This track crosses the two branches of the stream at points where its *thalweg* presents naturally a depth of from 7 to 8 mètres. (23 to 27 feet), and it avoids the necessity of raising the water-line of the canal much above the level of the two seas between which it is to form a communication. But it involves, as regards the canals for the supply and discharge of water, a multitude of supplementary works, which, from their extent and difficulty, are fully equivalent to the gigantic works proposed in M. Talabot's project. It moreover completely overturns the admirable hydraulic system on which the prosperity of Lower Egypt depends.

The free discharge of the waters after they have washed away the saline efflorescence which would otherwise render the land unproductive, is the primary condition of all tillage in Egypt; any tract of land lying below the level of the sea and becoming dried up by evaporation, must remain entirely barren, as is the case with the plains of Pelusium and Mareotis. The elevation of the water-line in the canal above the level of the Mediterranean would inflict sterility on a wide region of cultivated lands.

By receiving all the waters of the Nile to discharge them again into the sea, the canal would subject to artificial detention the waters of a great river, the flow of which is during the flood season sixteen times more than in the low-water period. How can it be conceded that a number of

narrow openings made through the banks would be sufficient to drain away the waters, when, during high floods, these waters, which at present encounter no obstruction, would lie stagnant over the country, ruining the crops and occasioning enormous losses? At each flood, either the banks of the canal would be swept away, or the seaboard would be swamped during the sowing-season. The periodical destruction of the canal and the permanent ruin of agriculture in Lower Egypt would accordingly be the inevitable consequences of adopting the track through the base of the Delta.

This scheme is moreover open to a great number of other objections. The spongy and unsubstantial nature of the soil which forms the basis of the Delta would render it very difficult to construct dams across the two branches of the stream and the embankment of the canal in its course across the Lakes. The fluctuations in the level of the Nile and of the Red Sea would necessitate the isolation of the canal from the river and from the sea, by means of walls, which, besides increasing the first cost of construction, would be a permanent source of obstruction, and would render the canal liable to intervals of disuse. It is very doubtful whether a depth of 26 ft. of water could be maintained in the two branches of the Nile throughout their whole breadth by the use of dredging boats. The passage from one lock to the other across a stream which, during the flood, flows at the rate of 3 ft. 3 in. per second, would be a difficult operation for large vessels, and would be frequently attended with damage. The great extension of the canal, with six locks intersecting its course, would unduly raise the cost of haulage.

The canal from Suez to Alexandria across the base of the Delta answers, therefore, but very incompletely to the neces-

sities of transit navigation, and would require an enormous outlay for its establishment and maintenance. Admitting the possibility of completing it successfully, it could not possibly be maintained, as it would bear within itself the germs of its own destruction, as well as of that of a portion of Lower Egypt.

SECTION IV.

THE DIRECT TRACK.

While the indirect tracks which we have just examined, together with all others of a similar description that could be imagined, present so many difficulties with regard to the hydraulic and agricultural systems of Egypt and the passage of the Nile, the Direct Track, on the contrary, presents, together with a shortening of the distance, facility of execution to a degree quite unlooked for, and the certainty of being easily maintained. In our opinion, if the direct track were not possible, it would be better, perhaps, to renounce all thoughts of joining the two seas by a canal for large ships.

The brief description we have already given of the general configuration of the Isthmus will suffice to show what should be the direction of the Ship Canal, in order to take advantage of every natural facility.

In the project, the studies for which have been made by MM. Linant Bey and Mougel Bey, the canal starts from the eastern portion of the Gulf of Suez. It traverses, taking a direction almost due North, the 20 kilomètres (12½ miles) which separate Suez from the basin of the Bitter Lakes. It traverses, also, these lakes, unembanked, and from the northern extremity of the Bitter Lakes it proceeds, cutting through the plateau of Serapeum, towards lake Timsah. This lake it also traverses, and winding round the plateau of El Guisr, it skirts the eastern border of Lake Menzaleh, and falls into the inner part of the Bay of Pelusium, between the ruins of ancient Pelusium and the Castle of Tineh.

The authors of the projects, guided by the soundings taken in 1847, had placed the outlet of the canal east of Tineh, it not having at that time been ascertained, that the required depths existed closer to the shore.

We have now transferred the outlet to a distance of 28½ kilomètres (17¾ miles) more to the West, for reasons which we will merely enumerate here, but which will be developed subsequently, when treating of the harbour, designated by us Port Saïd.

The first is, that, along this portion of the coast, the soundings taken by M. Larousse, the hydrographical Engineer, under the direction of M. Lieussou, have shown the existence of from 8 to 10 mèts. (26 to 32 ft.) of water, at from 2,300 to 3,000 mèts. (2,560 to 5,270 yards) from the beach. In the second place, it is certain that at this particular part of the coast it will be much easier for vessels to stand out, whatever wind blow from the offing. These two motives are all-

powerful. But we will not expatiate on this point here, as we shall subsequently have to return to it.

Before entering into the details of the question, we may, at this preliminary stage, point out, in a general manner, the advantages presented by the direct track.

In the first place, the direct track is shorter by two thirds than the others. Instead of 400 kilom. (280 miles), which is the average length of the canals proposed by MM. Lepère, P. Talabot, and Barrault, it extends to scarcely a third of this distance. Its entire course measures 147 kilomètres (92 miles), without a single lock.

The Ship Canal based upon this system would present to the trade of the world a complete solution of the problem. The route is shorter, and the fulfilment of its purposes is assured, at all times, without the possibility of obstruction, or interruption. The interests of the commercial world would be fully satisfied; and, as the whole works, under these circumstances, will be much less costly, the company undertaking their execution will derive sufficient profit to render the investment of capital remunerative. The tonnage at present passing round the Cape of Good Hope would pay, effecting at the same time a great economy, an amount of toll which at first starting will supply an adequate profit, and without adventuring a doubtful prophecy, it may be predicted, that the saving of distance, and the facilities of the route for long sea navigation, will infallibly bring about an increase of traffic, as is proved by the example of every enterprise in which, from the more convenient and rapid means of communication afforded, its amount has been augmented in an enormous ratio.

In another point of view the Ship Canal, being situated on the frontier of Egypt, and traversing merely the desert which bounds it to the East, cannot give rise to any of the calamitous consequences following in the train of all the indirect tracks running through the heart of the country. It will not in any way change the hydraulic system on which the necessary fertility of the country depends. Far, indeed, from disturbing any portion, it will rather extend and increase it, by conferring on Egypt a fresh-water canal in the Ouadee Toumilat.

Lastly, it will powerfully advance the political and religious interests of the Ottoman Empire, which will be placed in direct communication with the Holy Cities, the possession of which is one of the pledges of the Sultan's sovereign authority; and whilst it will increase the influence of the Grand Seignor, it will not induce that umbrage which the Egyptian Government might legitimately conceive at any project which would deliver up the interior of Egypt to the navies of other nations. It has been asserted (rather speciously than with sound reason) that the direct track was less favourable to the private interests of Egypt. For our part, we are not of this opinion; and were it indeed so, the fact would only the more redound to the honour of the Prince who generously consents to this sacrifice in favour of the general interests of European commerce and civilisation.

It is therefore our belief, that the Direct Track, such as we have succinctly described it, answers as completely as possible to all the requirements of the case, in whatever mode they be viewed; and we shall now justify this opinion by entering into the details of the project.

It behoves us to add, that the project of a direct track had been conceived as early as 1847, by M. de Negrelli, and that

his investigations resulted in a solution of the problem similar in its material features to that proposed by MM. Linant Bey and Mougel Bey.

SECTION V.

It will have been seen that, hitherto, in speaking of the Direct Ship Canal, we have all along reasoned on the supposition that the two seas were, saving the difference in the tides, on the same level. This is a point which it is desirable to bring forward in the clearest light, and we are called upon to render an account of the grounds on which our conviction is based.

After the levelling operations performed by M. Lepère in 1799, it was a generally-received opinion, for nearly half a century, that the level of the Red Sea at Suez during a high tide was higher by 9,908 mètres (33.49 ft.) than that of the Mediterranean at Pelusium, during low tide. When this result became known to the scientific world of Europe, at the commencement of this century, only a very few minds of superior order ventured to call it in question. Among the protests recorded against it may be cited those of the great mathematician Laplace, and of Fourier, the illustrious author

of "*La Theorie Analytique de la Chaleur*," both of whom, proceeding upon purely theoretical ideas of the equilibrium of the waters on the surface of the globe, refused to acquiesce in the possibility of such a fact. Laplace had never gone to Egypt, but Fourier formed one of the expeditionary corps; and although he had taken no part in the geodesic operations made on the ground, his opinion was nevertheless allowed to have great weight.

These isolated protests, in support of which no fact directly contradictory could be advanced, were not heeded. The difference of level found by M. Lepère and his colleagues was, moreover, perfectly in accordance with tradition received and handed down from antiquity. The origin of this tradition dates back at least as far as the time of Aristotle, by whom it was advanced in his *Meteorology* (Lib. I., cap. xiv., par 27), that the Red Sea was higher than the land of Egypt; and that Sesostris, who had commenced cutting a canal, was obliged to desist, as was Darius at a later period, from the fear that the Red Sea, mingling its waters with those of the river, should completely obliterate its course. This idea has been frequently brought forward since the time of Aristotle. It is not likely to have had any influence in causing the error fallen into by M. Lepère, although in more than one passage of his Memoir he countenances the apprehensions of the ancients, in which he appears to participate; and he even seems to regard these assertions as a sort of confirmation of the result of his personal labours.

A still more inevitable source of error consisted in the unfavourable circumstances under which M. Lepère had to carry through his operations. In twenty places he declares

in his Memoir how great were the fatigues he had to undergo, and what difficulties of every sort had to be conquered. He and his colleagues were subject to continual alarms, and they were constrained to break off their labours abruptly, on three or four occasions. The intervals during which they were suspended were very long. Thus the series of levels, begun to be taken on the 21st of January, 1799, were suspended after four days, and could not be resumed until eight months later, when they were continued from the 30th of September to the 17th of October. At the end of this period a fresh interruption occurred. An attempt was made, but in vain, to return to the work on the 19th of November, and it was not resumed until the 27th, proceeding from which time it was at last brought to a termination on the 6th of December following.

In addition to the dangers attendant on a state of war, other difficulties arose, attributable to the novelty of conducting operations of this description in such a climate, and the consequent neglect of all the necessary precautions it imposes. At one time the operators were obliged to return, their provision of water being exhausted; at another, they were led astray by the ignorance, or treachery of their guides. Moreover, M. Lepère confesses that the operations were conducted in a variety of directions by piecemeal; and that it became necessary afterwards to fit them together, in order to make up the levelling-book, by placing the observations in proper order, so that the line should run continuously from one sea to the other. As more than once it was feared that the undertaking could never be carried through, it is probable that at many points the work was hurriedly performed. As much as ten miles a day was done; far too precipitate a rate for so delicate an operation. Finally,

according to the admissions of M. Lepère, owing to the events of the war, these levels, which it was so necessary should be carefully checked, underwent no such process.

Less than this would suffice to deprive an operation performed under such circumstances, and with very imperfect instruments—as, for instance, a common water-level and measuring rods, instead of staffs—of that degree of accuracy which is indispensable. The labours of M. Lepère and his associates were not the less conducted with conscientiousness; and the remarks we are now making are rather to be taken in the light of a justification than a censure. The appendix to M. Lepère's work, in which he has given a long extract from the historical and geological diary of the levelling of the Isthmus, may still be consulted with advantage, and contains a quantity of very interesting details.

M. Lepère adopted as the basis of his levelling a horizontal plane passing 150 feet above the level of high tide at Suez, 5 Pluviose, year VII. (January 24, 1799). This tide was considered by him as corresponding with the maximum height of the Red Sea, although the equinox had not then commenced. The moon was then in her perigee, and was at the syzygy. The winds, then blowing from the south, concurred to augment the height of the sea in the gulf. The level of this high tide was referred to the upper surface of a tablet situated on the left side, within the northern portico of the Arsenal at Suez. The tablet being 5 ft. 8 inches and 3-12ths above the tide level, the co-ordinate of this datum-point was 144 ft. 3 in. and 9-12ths. This point was compared with the remains of the ancient canal at the level of its scum-line (*laisse*), 2,270 mètres (2,482 yards) north of Suez.

On this basis all the levelling operations were executed, first from the Red Sea to the Mediterranean; then from Mouqfar, in the Ouadee Toumilat, to Cairo; and lastly, from the Mekias, or Nilometer of Cairo, to the Great Pyramid of Ghizah.

It was from the whole connected series of these operations that M. Lepère deduced the general conclusion that the level of the Mediterranean lay 30 ft. 6 in. below that of the Red Sea, or 9,908 mètres (32 ft. 6 in.); the ordinate of the ebb tide at Tineh being 58,634 mètres (192.27 ft.); and that of the high tide at Suez 48,726 mètres (53.26 ft.) The number of stations from one sea to the other was not less than three hundred and forty-two.

The following are the terms already quoted by the authors of the project, in which M. Lepère himself passes judgment on his levelling: "Pressed for time, harassed by the hostile demonstrations of Arab tribes, constrained repeatedly to suspend our operations, and finally driven to make a large proportion of our levellings with a water-level and without the possibility of checking their accuracy, it is not astonishing that the skilful engineers who conducted these operations under circumstances so peculiar should only have arrived at an uncertain result."

For an interval of nearly forty years no further attempt at making a fresh levelling was made. In 1830, however, Captain (now Major-General) Chesney, after travelling across the Isthmus, and exploring it in different directions, asserted that the French Engineers must have been mistaken, and that this great difference of level could not really exist. A party of English officers, referred to by the Authors of the project, attempted, after the events of 1840, to make a

survey of the Isthmus, and declared that the level in both seas was identical. But the result of their observations could not be considered as decisive, from the imperfect nature of their instruments, the methods employed by them being those of the barometer and the boiling of water.

However, from 1846, the question assumed an entirely new phase. As early as 1841 M. Linant Bey had endeavoured, together with Mr. Anderson, the present Chairman of the Peninsular and Oriental Steam Navigation Company, to form a Company for cutting through the Isthmus of Suez. In 1846 a new company was formed, to execute, if possible, the plans of M. Linant Bey, and to ascertain the practicability of opening, according to his idea, an artificial Bosphorus through the Isthmus. The principal members of this association were Messrs. Stephenson, P. Talabot, and De Negrelli, our honorable colleague. The company ordered that, as a preliminary operation, a new survey of the Isthmus should be made, and the task was confided to M. Bourdaloue, whose reputation for experience in this species of work is so well established. In order that the investigation should be as complete as could possibly be desired to the European Engineers directed by M. Bourdaloue, there was added a brigade of Egyptian Engineers, two companies of sappers, and a company of artillerymen, placed under the orders of M. Linant Bey. The operations were conducted with the utmost care from Tineh to Suez, and afterwards from Suez to Tineh. The instruments were excellent, the staff numerous and well skilled, and as the different parties of engineers operated separately, there were repeated opportunities of mutually checking the result of the common labour. These checks amounted, according to the statement of M. Bourdaloue, to the number of six.

The result thus obtained was, it may be said, unerring, and M. P. Talabot undertook, in 1847, the office of communicating it to the scientific world. The Red Sea and the Mediterranean, it was now established, were level, or very nearly so, as Laplace and Fourier had believed, and the levelling of 1789 was therefore erroneous.

From 1846 to 1856 as many as eight levellings may be reckoned, in various directions, from one sea to the other, viz.:—five between the Gulf of Pelusium and the Red Sea, in a direct line, and three taking an indirect course, passing through Cairo, so as to terminate at either Rosetta or Damietta on the one hand, and at Suez on the other; all establishing the same fact of identity of level.

The five levellings in the direct line are—

1. That of MM. Bourdaloue and Linant Bey, in 1847, from Tineh to Suez.

2. That of MM. Gabolde and Fremont in 1848—a check to the preceding, and going in the contrary direction from Suez to Tineh.

3. That of M. Linant Bey, in 1853, once more checking the whole operation, by order of the Egyptian Government, and in compliance with the request of M. Sabatier, the French Consul-General.

4. That of Salam Effendi, on his first campaign in 1855, under the direction of M. Linant Bey, being ordered for the future labours of the International Commission, and extending from Pelusium to Suez.

5. Lastly, that of Salam Effendi's second campaign in the course of 1856.

The three levellings, taking the indirect line, that is, passing through or starting from Cairo, are :—

1. That of Tahil Effendi in 1846, proceeding from Rossetta to Cairo through Beheveh, in conjunction with that of M. Bourdaloue in 1847, taking the line from Tineh to Cairo, across the Ouadee Toumilat.

2. That of Rhamadan Effendi in 1849, from Suez to Cairo by the post road, connected with that of M. Bourdaloue in 1847, from Cairo to Tineh by the Ouadee.

Undoubtedly, these levellings are not all characterised by the same precision, and are not to be invested with equal authority. There is, however, a general agreement between them, the greatest difference amounting only to 0·94 mètre (3·08 ft.), and the result to which they all tend now stands beyond dispute. The levellings to which the greatest interest attaches, next to that of M. Bourdaloue, are those of M. Linant Bey, undertaken to make an award, as it were, between the operators of 1847 and those of 1799, and that of Salam Effendi, undertaken for ourselves. The scientific world had become interested for the honour of the Egyptian Commission, attainted by the imputation of so considerable an error, and it was in obedience to motives involving a point of honour, that M. Sabatier sought, in 1853, the official verification intrusted to M. Linant Bey. We have had before us the level books of M. Linant Bey, and it is shown by them, that between the special observations noted down by himself, and those of 1847, the differences at the various datum points marked over a distance of more than 30 leagues (75 miles) are insignificant in amount.

It is from the combined evidence of these operations that we have deduced our conviction, that the ordinary mean level of the Mediterranean at Tineh is 2·32 mètres (7 ft. 7 in.) above the datum point, taken in front of the hotel on the quay at Suez, at the right corner of the stairs. For more ample details, however, we refer the reader to the special calculations made to determine the *regime* of the waters in the Suez Canal, which will be found at the end of this report.

SECTION VI.

THE character of the surface of the Isthmus having now been shown, the next important consideration is to ascertain the nature of the soil which the canal will traverse, being carried to a minimum depth of 8 mètres (26 ft. 3 in.)

In this particular, the labours of the Egyptian Commission are anything but satisfactory. M. Lepère's Memoir, it is true, supplies several curious facts relative to the superficies of the Isthmus. But scarcely any attention was paid to the nature of the subsoil, and only two excavations were made in the bed of the ancient canal—one being at station 16, and the other at station 21. These excavations were not very deep, and seem to have been made rather out of curiosity, than in pursuance of any systematic plan of investigation. They were carried to a depth of 4 or 5 feet at the utmost, and the results furnished by both were almost exactly similar. In the first (station 16) was found

greasy, argillaceous, saline, and very moist sand. In the second, which was somewhat deeper (station 21), were discovered gypsum, in strata, and rather compact clay, mixed with sand, and impregnated with saline moisture.

These are all the geological data which were gathered by M. Lepère. It is quite clear that he saw no necessity for seeking to acquire more. The object he proposed to himself being the restoration of the ancient canal, following its course as nearly as possible, he was sufficiently assured that the soil was fitted for the retention of water, it having been so employed before. The banks still subsisting of the canal of the Pharaohs afforded adequate and undeniable evidence on this point.

In our own case, the circumstances were not the same, and one of the principal subjects to which our care was constantly devoted was that of boring. We caused as many as nineteen trials to be made between the Red Sea and the Mediterranean. First, in the roadstead of Suez; then in the plateau which separates Suez from the Bitter Lakes; in the basin of these lakes; in the plateau of Serapeum; in the plateau of El Guisr,—the summit-level of the Isthmus; and, lastly, in Lake Menzaleh. The register of the borings appended to this Report will supply a complete and detailed account of the works undertaken in this respect. We shall content ourselves here with giving a summary sketch of them.

The entire stratification of the Isthmus of Suez belongs to the tertiary formation, as does that of Lower and Central Egypt, and the great plateau of the Lybian desert.

Two borings were, in the first place, made in the roadstead of Suez, on the course of the future channel; one in

the bank, which lies to the left on entering the harbour—the other more to the North, in the bank which lies isolated, opposite Suez, to the left. The first, 11 mètres (36 ft.) deep, exhibited, from the surface to the bottom, yellow agglutinated sand, coarse and somewhat muddy sand, very fine ochrey sand, and yellow argillaceous sand. The second, 12 mètres (39 ft. 4 in.) deep, gave shells, gravel, and coarse agglutinated sand, forming a bed of hard rock 3.50 mètres (11 ft. 6 in.) thick, yellow sand slightly agglutinated, coarse red sand, and sand mixed with fine gravel of some consistency.

Such is the nature of the soil to be excavated by the dredging-machine in order to form the channel in the roadstead of Suez. No real difficulty will be encountered, except as regards the 11½ feet of agglutinated sand closely approaching the hardness of stone. This material is not coral, as has been sometimes asserted, but an extremely hard substance, and its excavation will require a greater amount of labour than in any other portion of the line.

Northward, and to the West of this town, stretches a plain, presenting a slight inclination, both in the direction of the Isthmus and of that part of the Gulf comprised between Suez and the Attaka mountains. This plain is completely sterile, and is formed of sand and shingle, the sand largely predominating. Starting from Suez, and following the borders of the Gulf on the northern side, sand is met with which appears to be derived from deposits left after unusually high tides. It is impregnated with saline moisture, which gives it compactness.

The third boring situated at 8½ kilomètres (5¼ miles)

from Suez where the line crosses some of the canal of the Pharaohs, and in the route of the returns from Egypt to Mecca, rises 11 metres 36 feet in 3 miles of clay, mixed in various proportions with sand, following a slight stratum of sand not much undermined. The two embankments of the ancient canal in some places standing 50 metres 164 feet apart, stand out more and more distinctly in relief in advancing towards the North, and in some places the ridge they form rises to a height of not less than five or six metres 16 to 19½ feet. Traces of crystallized sulphate of lime begin to appear, also a certain quantity of shingle, a small portion of which has penetrated into the mass of sand.

Boring No. 4, at about 2 kilometres 1¼ miles from Suez, likewise, after 2·20 metres 7½ feet of red sand, gave little else than clay, which was in some parts compact, in some sandy and filtered, in some brown and very unctuous. The boring here was carried down to a depth of nearly 16 metres 52 feet. Over the surface of the soil at this spot are found scattered calcareous fragments varying in size, but they are speedily lost sight of as the Bitter Lakes are approached.

Borings 3 and 4 clearly indicated the nature of the soil to be excavated in the portion of ground separating the Red Sea from the Bitter Lakes. It consists almost entirely of different species of clay, varying in compactness, and capable of resisting the action of currents of sufficient force to destroy embankments of sand. Towards the most elevated point of this region is found gravel in sufficient abundance, and coarse in texture, but it becomes less abundant towards the basin of the Lakes, and subsequently disappears altogether.

The Bitter Lakes, extending to a length of not less than 40 kilomètres (25 miles), and long since dried up, are separated into two basins: a small one first, then one larger, longer in shape and deeper. The depressing the soil by which they are formed is at first not very perceptible to the eye, and it is even difficult to discern it. The appearance of the soil, however, no longer has the same character. The bottom consists of yielding sand impregnated with salt. To the right and to the left a horizontal ridge marks the ancient surf-line of the waters. Shells, of which there had been no trace since Suez, re-appear in large numbers, and vegetation, hitherto equally deficient, appears at intervals —distant and rare at first, but growing more and more abundant until the northern extremity of the Isthmus is reached. Small rhomboidal crystals of sulphate of lime are scattered more, or less abundantly over the bottom of the lakes, and in the smaller basin, in particular, these crystals are of a needle-shape.

Four borings effected within the small basin, the surface of the soil being either level with the Mediterranean, or at 4·63, 4·50, and 5·40 mètres (15 ft. 2 in., 14 ft. 9 in., and 17 ft. 8 in.) below, gave, with sand and shells and sulphate of lime, and light brown clay in various degrees of admixture with sand. In some parts this clay resembles the sediment of the Nile.

The length of the larger basin alone is about 25 kilomètres (15½ miles.) The first portions of the bottom, nearest the edge, are covered with sand, shells, and crystals of sulphate of lime. The deepest part is filled with a thick bed of sea-salt. Ridges of small shingle and shells, similar to those

of the sea, mark the shore of the ancient lake. These three ridges, rise one above the other at different heights.

Two borings were made in the lowest part of the Bitter Lakes; they were the ninth and the tenth. The first to a depth of 2·20 mètres (6 ft. 9 in.), exhibited agglutinations of shells 20 centimètres (8 or 9 in.) thick at the most, and the remainder sulphate of lime, in very fine needle-shaped crystals with sea-salt. The other 3·50 mètres (11 ft. 7 in.) in depth, brought up absolutely nothing but sea-salt, which in this part appears to be 7 or 8 mètres (26 ft.) deep, and might be easily and profitably worked. The surface of the soil where these two borings were made is from 6·69 mètres (21 ft. 10 in.) to 7·35 (24 ft.) above the level of the Mediterranean. These masses of salt are sometimes superposed on deposits of sediment from the Nile, and may have been produced by the action of subterraneous springs.

The great basin of the Bitter Lakes being left behind, the plateau of Serapeum appears; and, commencing from this point, which forms almost the centre of the Isthmus, little else than sand occurs as far as the Mediterranean, except at the site of boring No. 19, where marl is found. Of this fact all the remaining borings give evidence. Thus, beginning with boring No. 11, sunk at the border-line between the Lakes and Serapeum, only sand and minute gravel were found to a depth of 8 mètres (26 ft. 3 in.), and sand of various degrees of fineness somewhat mixed with clay for 3·50 mètres (11 ft. 5 in.). The elevation of the soil above low-water mark in the Mediterranean, at this spot, was 3·40 (11 ft.) Another boring (No 12) made at the other extremity of the Serapeum, on the slope inclining down to Lake Timsah, also gave only sand mixed with fine gravel; sand varying in the size of its particles; and white or red sand.

Completely across the plateau of Serapeum, to the north, above Lake Timsah, is the point called Sheik-Ennedec, so called from the tomb of a Santon of that name. This point deserves notice, from the fact of an opinion having been entertained that it would yield materials for the construction of the canal. Such, however, is not the case. It is true, indeed, that in this place a bed of calcareous stone exists: but it is not more than 1·50 mètres (4 ft. 10 in.) in thickness. It forms the crown of a hillock formed of of stratified sand without any consistency. These stones, specimens of which were laid before the International Commission, might be good enough to form the heap of materials honoured with the name of a tomb; but they can not, from their want of substance, be used for any engineering structure. Barely could they be employed to form the *revêtement* of the banks of the canal. A species of perfectly similar limestone is found, moreover at the summit of the sand-hill, which rises in the central portion of the lake. But this also is equally deficient in the necessary qualities for useful application, and all hope must be abandoned of obtaining materials from the Isthmus itself, fit for any other purpose than the one mentioned above.

At the period when Lake Timsah was visited by our colleagues, its southern portion was dried up, and only a small quantity of water remained in the northern part. This was owing to the rise of the Nile having been less than usual in 1855, its waters that year therefore had notreached so far as the lake. But traces of its presence on former occasions were every where visible in the deposits of sediment left at the base of the sand-hills and round the foot of the tamarisks, similar to the indications in the plains of Upper Egypt. The

sand-hills which intersect the Lake must be very ancient, as on one of them, on which our colleagues halted, large quantities of ancient pottery were found. The water found in Lake Timsah is much more saturated with salt than is that of the sea; and it emits the same odour of sulphuretted hydrogen which is exhaled by the water in harbours where the sea is stagnant and unaffected by tides. This excessive saltness does not, however, prevent the growth of reeds, which spring up in abundance on its shores.

The borders of Lake Timsah appear to be completely fixed throughout their extent. It is probable, however, that in former times the Red Sea advanced as far as these regions; shells similar to those inhabiting that sea, and which do not exist in the Mediterranean, are found beneath the mud. To the west there is a range of shifting sand-hills extending to the length of about 2 kilomètres (1 mile 2 furlongs), and distant from the lake 400 or 500 mètres (437 to 543 yards).

Two borings (Nos. 15 and 16, a somewhat argillaceous) sunk in the lake towards either extremity, afforded only sand of various colours.

North of Lake Timsah is the plateau of El Guisr, which forms, the summit-level of the Isthmus; its elevation above the Mediterranean at low-water is 15 mètres, (49 ft.) Like all the higher portions of the plateau to the north of the Ouadee, it consists of a vast bed of sand protected from the action of the wind by the plants and small gravel with which it is covered. It presents every appearance of complete stability, and it forms a not of a connexion between the Ouadee and the deposits of sand stretching

towards Syria and the East as far as the Arabian chain, of which it seems to form a component part.

The boring sunk in the plateau of El Guisr was for obvious reasons, deeper than any of the former. It was carried to a depth of 23.35 mètres (76½ ft.) Boring No. 18, proceeding from the surface downwards, exhibited sand alternating with slight layers of clay and sulphate of lime, minute gravel, a great quantity of fine sand, and, for the last four mètres (13 ft.), sand almost of the compactness of stone and shingle.

On the upper portion of Serapeum, traces are discernible of embankments thrown up, at some ancient date, for the formation of a canal. This canal was intended to connect the Red Sea with the Pelusiac branch, and the communication, thus established between the two seas, would have been more direct. As far as can be ascertained, this is probably the canal of Nechos, as it was called, but there is no historical evidence to whom the attempt to carry out this undertaking is to be attributed. It is certain, however, that it was made either by the Pharaohs or Calif Amrou. The banks of this canal are as plainly discernible as those north of Suez, as far as the Bitter Lakes, and they bear equal testimony to the stability of the soil in its present state, which has continued unchanged for so many centuries.

From the plateau of El Guisr to Pelusium, a distance of nearly thirteen leagues, (32½ miles,) the surface of the soil exhibits a series of undulations with very gentle slopes. In no part is there any considerable alteration of level. The gravel becomes gradually finer, and at last disappears. The sand, which is tolerably firm, is not at all movable along

the line of the canal. On every side the peculiar vegetation of the desert is visible, and the bushes grow so thick that the camels are scarcely able to pass through them. The fuel thus afforded may be usefully employed in the course of the works.

Two borings were sunk in Lake Menzaleh, one at its southern extremity, and the other eight leagues further (28 miles), at the point of land where the canal is to fall into the Mediterranean. The first, which was made at a level with that sea, showed a small quantity of Nile mud and sandy clay, and a great deal of sea sand. The second presented sea sand, sand mixed with mud, and, then mud, with an admixture of sand.

Thus, the Suez Ship Canal will have to traverse throughout its entire course of 147,956 metres (161,827 yards), two principal descriptions of soil: first, clay, from Suez to the Bitter Lakes; next, firm sand, from the Bitter Lakes to its outlet in the Bay of Pelusium.

With respect to the shifting sands, which, according to a commonly-received opinion, are expected to jeopardise the existence of the canal, they are a chimera, without the slightest foundation in fact. The observations made on the spot by our colleagues show that the entire soil of the Isthmus is perfectly stable throughout, being rendered so either by the gravel, or the vegetation with which it is covered. What is still more conclusively demonstrative of this fact is the existence, after a lapse of so many centuries, of such considerable vestiges as are still left of the ancient canal works. Were the sands on the surface of the Isthmus subject to movements capable of producing such effects as have been imputed to

them, these vestiges would long since have disappeared. Instead of being, as they are still, from 5 to 6 mètres (16½ to 19½ ft.) in height, they would have been buried and become invisible, in common with so many monuments in several other parts of Egypt. The very existence of the extensive depression forming the Bitter Lakes proves that these displacements of sands by the action of the wind can be but of little importance or this cavity would long ago have been filled up. Another fact, no less indicative of the truth, although, materially speaking, very slight, and one which was in like manner ascertained by our colleagues, is, that the traces of an encampment, made the preceding year, in the neighbourhood of the ancient Migdol remained completely intact, and that the small ridge raised round each tent, far from having become obliterated, presented as sharp an edge as though it had been raised the previous day.

Thus, then, neither the surface of the soil, nor the nature of the subsoil offer the least impediment to the construction, or the maintenance of the Canal.

SECTION VII.

THE Authors of the project were called upon to decide between two different systems, according to which the Canal across the Isthmus could be constructed.

The Canal might either be constructed with a summit level and fed with water from the Nile, or excavated, so as to bring the two seas into direct communication, with, or without locks at the extremities.

In adopting the latter system MM. Linant Bey and Mougel Bey had not declared the motives which induced this preference. The character of the ground, be it observed, is nevertheless as favourable as it could well be to the construction of a canal with a summit level. The Commission have, therefore, considered it their duty to inquire, whether, or not it would be proper to adopt this system in preference to the other.

By constructing a canal with a summit level, it is evident, that a considerable economy would be effected in the quantity of the earthwork. The cubic content of earth to be moved would be considerably reduced. The canal would have to be excavated to a considerably less depth, and consequently, the inconvenience resulting from the infiltration of water would be much less. But the saving would unquestionably be greatly diminished by the expense which would have to be incurred in embanking the canal across

Lake Menzaleh, and flush with the basin of the Bitter Lakes, round which it would wind, and by the cost of establishing the locks to be constructed on each extrimity. It would be quite impossible, moreover, to take advantage, as in the case of ordinary canals, of the configuration of the ground in order to select the most advantageous site for the locks. They must of necessity be placed at each end of the canal, to allow of the employment, under the most favourable conditions, of steam-tugs for the haulage of the ships.

Under any circumstances, the saving would certainly still be in favour of the canal with a summit level, and this system ought undoubtedly to be the one adopted, did the ultimate decision of the point depend entirely upon considerations of expenditure. But there are several serious objections against the adoption of this plan.

The canal would require to be fed with water from the Nile. This water contains, as we have already noticed, an average amount of mud, equal to 0·004. Admitting that there would be a traffic of 6,000 ships per annum, backwards and forwards; and supposing two locks of 2·50 mètres (8 ft.) fall, each extremity of the canal, the quantity of water used annually in the navigation would be, $2 \times 6{,}000 \times 100^{m} \times 21^{m} \times 2{\cdot}50^{m} = 163{\cdot}000{\cdot}000$ cub. m.(=8,2,40,4,000 cub. yds.)

Estimating as we have done in the foregoing, the loss by evaporation, filtration, and accidents, at 0·03 per square mètre and per day; the surface of the canal being 12,160,000, the total loss per annum would be..... 133,152,000 cub. mèts. (=174,162,816 cub. yds.)

The quantity of water to be annually supplied to the canal from the Nile, would be.....	196,152,000 cub. mèts. (=256,566,816 cub. yds.)
And the quantity of sediment deposited by this amount of water, at the rate of 0·004, would be	784,000 cub. mèts. (1,025,090 cub. yds.)

This quantity of sediment would have to be removed annually, causing an expenditure of at least 1,000,000 francs (£40,000); and it would be requisite to maintain permanently in the canal from 10 to 12 dredging machines. This method, therefore, of feeding the canal from the Nile affords sufficient grounds for rejecting the summit level system. But it is open to still further objections.

It is evident, that as regards the greater portion of the canal, the only material that could be employed to form the embankments, would be sand. Now the peculiarities of a sand embankment are well known. No matter what precautions may be taken, they never can offer sufficient security. The slightest variations in the level of the water might cause land slips in the outside portion of the embankments, and occasion their destruction. It is true, that the deposits of sediment from the Nile water on the inner slope would eventually render them impervious; but until this had taken place, there could be no security for their stability.

But what is chiefly to be apprehended is the damage that may be inflicted by evil-disposed persons. We have only to suppose an Arab shepherd flushed with the spirit of mischief and a few strokes of a pick-axe would empty the

canal in a few minutes. But even leaving out altogether the supposition of malicious intention, which is nevertheless a contingency to be taken into consideration, a sufficient source of peril exists in the wild animals of the desert, which in making their burrows, so abundant in every portion of the Isthmus, might occasion the most serious disasters. Admitting that no accidents occurred, the establishment of an effective guard would nevertheless entail a very heavy cost. As there would be a perpetual danger of the banks bursting, it would be necessary to organize a system of watching similar to that which is established on the Adige when the rise of the waters assumes a threatening appearance. In the latter case, however, there is at least the population of an entire district at hand who are not only thoroughly devoted, for they would perish but for these works, by which their property is protected; but they are moreover thoroughly well skilled in the art of construction. In the desert no such resource would be at hand.

Another difficulty which a canal with a summit level would present, is involved in the peculiar circumstances under which embankments must be made in the portion crossing Lake Menzaleh. The embankments would require here to be raised on a foundation of soft mud, and be themselves formed of a similar species of mud. Their construction, unless works of the most costly character were resorted to, would therefore present difficulties which may be considered very nearly insurmountable.

Lastly, there is one more serious objection against this form of canal, namely, that it must be closed by lock-gates, and that consequently it would be subject to all the inconveniences experienced in ordinary canals.

The authors of the project have done rightly, therefore, in not adopting this system in their scheme for traversing the Isthmus of Suez.

SECTION VIII.

THE QUESTION OF LOCK GATES AT EACH END OF THE CANAL.

It being shown that the direct canal must be fed with sea water, two systems at once present themselves. The canal can be made with Lock-Gates at each end, at Suez and Pelusium; or it can be left completely open, offering to navigation a Bosphorus formed by the hand of man.

Both these systems have advantages and inconveniences, which we will proceed to examine. We shall first take the system of lock-gates, which is that adopted by the authors of the project.

Lock-gates at each end would present this advantage—and a very considerable one—that the expense of construction would be diminished, the execution of the works be more rapid, and the maintenance of the canal be easier. By admitting of the level being raised to an additional height of from 1 to 1·50 mètres (3 to 5 feet), a saving of 17,000,000

cubic mètres (22,236,000 cubic yards) would be effected in the earth work. It would prevent the silting of the canal, or its filling with mud either at Suez, or Pelusium. By intercepting all communication from without, it would insure a perpetual calm throughout the whole extent of the canal, disturbed by neither currents nor tides, and it would thus procure the most perfect security.

But these advantages are rather apparent than real. In the first place, according to the calculations made, the water-line could not be perceptibly raised if the course of the canal were interrupted by the sheet of water of the Bitter Lakes; and it could only be raised 0·64 mètres (2 feet) if the canal ran an unbroken course from one sea to the other. In the first case, which is that of the project, the anticipated saving would be insignificant; in the second, it would not amount to 4,000,000 francs (£160,000), and would be swallowed up by the cost of the embankments to be executed across the Bitter Lakes. In reality, therefore, no compensation would be offered for the expense of constructing the lock-gates. To avoid delays, which it is but too easy to foresee, at least two locks parallel with each other would be required at Suez, and the same number at Pelusium; and it has even been proposed that there should be four—two large and two small—to be quite secure against any interruption of the navigation. The cost of first construction, the maintenance, and that of a numerous staff for working the locks — would entail a considerable amount of expenditure for a result of doubtful utility, attended with certain and evident disadvantages.

It would, moreover, be extremely difficult to maintain the additional height of 0·64 mètres (2 feet) for permanent use.

When favourable winds prevail, vessels will arrive in large numbers. At Constantinople, when the wind is S.W. and the passage of the Dardanelles and Bosphorus is easy, as many as from one to two hundred vessels may be counted coming up in the course of the day. To take a case more analogous still, it is not a rare occurrence, when the N.W. wind prevails, for sixty, or eighty vessels to enter the port of Alexandria in one day. It may be anticipated, without fear of exaggeration, that very frequently during a prevalence of favourable winds, vessels will crowd also to Suez, or Pelusium when the ship canal is open. These successive arrivals would necessitate constant working of the locks, which would diminish the additional height of water obtained; so as to exhaust it altogether during the low-water season. It would be requisite, therefore, in prudence, to excavate the canal to as great a depth, under the system with locks, as in that which dispensed with them.

On the other hand, the danger of silting and of the formation of mud deposits, from which it is intended to preserve the canal by gates, to be closed at will, is not, nearly so formidable as has been supposed. In the first place, the Red Sea can only carry along a very small quantity of sand, and no mud at all. Its waters in the roadstead are constantly limpid, and the firm hold of anchors in the bottom prove that it is little subject to disturbance, even during stormy weather. The deposits of sand and mud which form the shore line of the roadstead or line the bottom do not experience any perceptible augmentation, or displacement. The general configuration of the beach and of the banks is permanent; the current and the surge being weak. There is nothing, therefore, to fear from the Red Sea, and the sand which may be brought up by the

waves, when they rise. will be deposited in the channel. It may be rolled along the bottom by the currents produced by the set from Suez towards the Bitter Lakes; but it would never go beyond. It would seem superfluous, therefore, to shut out its access to the canal by lock-gates.

The case will be very much the same as regards the Mediterranean, and although there is a great deal of mud brought down by the Nile into that sea, it is probable that this mud will not make its way into the canal. It must be remembered, in the first place, that leaving out exceptional cases, the current will always be from the Red Sea to the Mediterranean, and will, consequently, tend to drive back the mud-charged waters. During gales from the N.W., the mud might be borne along by the current from the Mediterranean towards the Bitter Lakes. But the creation of such currents would only be an exception; and the counter current would, in all probability, bring back the greater part of this mud into the sea. As regards the sand, it will be seen when we treat of Port Saïd, in the bay of Pelusium, that the Nile brings down very little sand to its outlet. Although, from recent experiments made at Boulogne, it has been demonstrated that sand can remain suspended in water, it is very certain that it is generally, soon precipitated from its specific gravity. In the Mediterranean there is scarcely any movement of sand, otherwise than along the bottom and from the action of the swell, and it ceases directly the agitation of the waters diminish. Thus, at Malamoca and Cette it is deposited in the outer harbour, and does not reach the lagoons. This will be the case at Saïd; any small quantity of sand that may find its way through the jetties will not reach the head of the canal. Moreover, storms are of rare occurrence in the Bay of

Pelusium, there being, at the utmost, not more than two, or three in the year. Whatever violence may be attributed to these, they can never occasion any serious damage, as they are of short duration, and their action upon the mud, will, moreover, be counteracted by the current of the canal; for it is certain that this will only, in exceptional cases, set from the Mediterranean towards the Bitter Lakes.

Thus, then, locks while costing a large sum, would not obviate the inconvenience of sand and mud, and would still remain with their usual disadvantages. Locks must always retard the progress of vessels, by the time occupied in working them, or by the interruptions to traffic caused by repairs; and, moreover, they are inconvenient obstacles to the entrance and departure from the canal. It is impossible to admit their employment for a grand Ship Canal, to which thousands of vessels will direct their course, except it can be were demonstrated to be an absolute necessity.

The question, therefore, as regards the use of locks, resolves itself into an inquiry, whether the canal, without being closed, would offer every requisite for its maintenance; and whether the current, which would be established from one sea to the other would, in the ordinary state of things, or even under unusual circumstances, have any effect tending to the destruction of the banks. If a simple and effective means, could be discovered, of counteracting and neutralising all injurious results from the action of the water, a great advantage would be obtained; and while it obviated the necessity for locks, it would it in some sort replace them in their useful effects. This is precisely the expedient believed to have been found in the

Bitter Lakes, which are situated at a distance of five leagues (12½ miles) from Suez, and appear to be capable of producing the desired result. The waters of the Red Sea may be introduced into them with all due precaution; and when once the lakes are filled over a surface of 330,000,000 square mètres (394,690,890 square yards), a constant level would be maintained, which would serve as a sufficient regulating power to the action of the waters. Consequently the rapidity of the current would be increased southward of the lakes in that portion of the canal which is cut through clay; and would be diminished in that portion which is cut through sand.

We have, therefore, decided in favour of a canal without locks, and interrupted in its course by the vast sheet of water of the Bitter Lakes.

To this system several objections have been made. The Bitter Lakes, it has been said, when filled with the waters of the Arabian Gulf, would form a species of inland sea, the waves in which might still run to a considerable height, and Ships would have difficulty in crossing it when the weather was unfavourable. In proceeding from Suez to Pelusium northerly winds would be chiefly encountered, and these winds prevail throughout almost the whole year. In the lake of Alkmaar, in Holland, it was found necessary to embank the canal which traverses it, in order to ward off the shock of the waves, which were of sufficient magnitude to be formidable even to large vessels. The lake of Alkmaar is nevertheless an inland lake, and has no communication with the sea. The embankments of the canal are not continuous, but present openings at regular intervals, in order to bring the waters of the lake on the same level with those of the canal;

they are lined with stone and serve only to prevent the waves extending to the course of the canal. Again, by leaving the Bitter Lakes entirely open, the haulage is necessarily interrupted; whereas it ought, if possible, to be carried on without break along the banks of the canal. Mariners, especially in the case of coasting vessels, would always prefer the haulage being continuous.

The embankment of the canal, moreover, in its course through the Bitter Lakes, would not be so expensive as might be imagined. By a skilful determination of the slope, not more than 4 or 5 millions of cubic mètres (5,000,000 to 6,500,000 sq. yds.) of earthwork will be needed. They might be lined with stone, not only from the quarries of Attaka, but from the bed near Suez, which is 3.50 mètres ($11\frac{1}{2}$ ft.) thick, and 100 (327 ft.) long, and would constitute an inexhaustible source of material close at hand.

Fears have been also expressed as to the manner in which the lakes should be filled, when the waters of the sea were to be let into them. Apprehensions are entertained that the velocity of the waters rushing in would destroy the canal, and cause landslips which might probably fill it up. The canal with the dimensions which have been given to it not having the section of *equilibrium in rivers*, it may be feared that its sides would assume the slope of a natural stream.

In rejecting the use of locks it will be necessary to guard against the presumed current between the Red Sea and the Bitter Lakes, and this interval being accordingly lined with stone-pitching, it is feared the stone will

have an injurious effect on the copper sheathing of vessels. The various precautions adopted in harbours to avoid the employment of metalled slopes are referred to—such as making all the locks with vertical sides, and erecting stockades of pilework in front of those slopes, which are revetted with stone, or even with bricks.

Such are the principal objections brought against the system of a canal without locks; the natural concavity presented by the vast hollow of the Bitter Lakes being rendered available to avoid the necessity of any works of canalisation for a length of 18 kilometres ($11\frac{1}{4}$ miles).

To these objections it may be replied, that the dangers of any storms that may arise in this inland sea are exaggerated. The waves can never be otherwise than small, as, from the want of depth on its shores, they cannot acquire any development. The passage across, in the direction of Suez, will be favoured by the continuance of northerly winds, and that towards Saïd by the permanent current running from the south. Neither dangers nor difficulties are to be feared for sea-going vessels performing this passage; since the vessels in the Languedoc canal, which are mere canal boats without sails, or any sailing qualities whatever, navigate the lake of Thau, where the depth of water is considerable and the winds are extremely violent.

In order to form an accurate idea of the action of the winds upon the Bitter Lakes, the character of the winds habitually prevailing in the Isthmus and about its approaches, must be borne in mind. Storms are, as we have already remarked, always of rare occurrence and very transitory.

But, in addition to this, we must also direct our inquiries to the well-known example of the roadstead of Suez. The prevailing wind here, in all seasons of the year, is from the N.N.W.; from March to December, it blows almost exclusively from that quarter; and from December to March it alternates with breezes from the W.S.W. and S.S.E. It is satisfactorily established that the N.N.W. wind, which sweeps freely over the low lands of the Isthmus, is never dangerous. With respect to the S.S.E. winds, or those which blow from the offing, they are also free from violence. During southerly winds the anchorage is not more disturbed than when they are from the North, as is proved by the log-book of the English corvette stationed uninterruptedly, for the last three years, as a coal-store in the bay of Suez.

It may be conjectured therefore that on the Bitter Lakes situated at the utmost, 5 leagues ($12\frac{1}{2}$ miles) from Suez, without any considerable rise in the surface of the intervening region, the regimen of the winds will be about the same as in the roadstead of Suez; and this regimen as we have seen is not characterized by any formidable peculiarities.

The example brought forward in the Lake of Alkmaar, in Holland, may perhaps appear not very conclusive, as the winds prevailing in Holland are far more violent and frequent than those of the Isthmus of Suez.

It is true that the interruption to the haulage will be an inconvenience to small crafts, and even to vessels of a larger size. But the deficiency will be supplied by steam tugs, which will offer the advantages of a less expensive mode of traction, and the vessels will be brought in and out by them without difficulty.

With respect to the cost of embanking the canal across the lakes, it no doubt forms an important part of the question. But it is not here, nor in the presence of the result which is sought to be obtained, that we should be justified in taking it too anxiously into consideration. Were it sufficiently demonstrated, that the existence of the canal itself, or the proper facilities for its navigation depended on the embankment across the lakes, it would be necessary to make the embankment, without any reference to the question of cost. But to no one has it appeared to wear this character of absolute necessity. We reject the measure, not because it would be too expensive, but because it does not appear to us of any utility. In our eyes there is every certainty that the navigation of the lakes will be effected without any danger requiring to be guarded against; and we believe that in leaving them completely open they will the better co-operate towards the object they are intended to serve, namely the neutralisation of the tidal currents in the canal joining the two seas.

The alleged difficulty of admitting the waters of the sea into the lakes gives us little uneasiness. To M. Lepère, this operation, the idea of which was entertained by him, seemed an easy one and that opinion is repeated in his memoir on several occasions. To us it appears equally so. In the first instance, as M. Lepère proposes, only a narrow section need be made, leaving it to be widened subsequently to the required dimensions of the canal.

The plateau near Suez, being of clay, would form a natural batterdam, sufficiently strong without being too thick, by the aid of which the admission of the waters into the Bitter Lakes might be regulated. Several months might be

occupied if necessary in the process of filling them, should it be feared that by proceeding too rapidly the banks might be injured. Admitting even that the current should, in the first instance, wear away the sides, the landslips that would follow would only widen the canal; nor could these landslips which might be cleared away by dredging, be of any very considerable extent in a clay soil.

The objections raised against the stone lining are of a more serious character, and nothing can be more reasonable than that in the construction of sea works, everything should be avoided which may tend to injure the sides of vessels. But it must be kept well in view that in this case the banks will be 100 mètres (328 ft.) apart; and that within this width two vessels making an opposite course, can easily pass each other without being driven against the sides. We must add also that the pitching will not extend very far, and will only protect a portion of the length of 20 kilomètres (12½ miles), between the Gulf of Suez and the Bitter Lakes. It is to dissipate any fear that might still remain on this point, that we have given an additional width of 20 mètres (65 ft.) This enlargement will not be very expensive, and we have adopted it the more readily, as it applies to the only portion of the canal throughout its entire course, where the current would be sufficiently strong to affect the stability of the banks.

Having thus met and disposed of all objections, we have now to treat of the system on which we have finally decided.

The entrance to the canal at Suez would be left absolutely free, and it would be equally so at its other extremity in the bay of Pelusium. The width of that portion of the canal

lying between the Arabian Gulf and the Bitter Lakes would be 100 mètres (328 ft.) at the water line, and revetments in stone would be made wherever the sand, or clay might not seem sufficiently compact to resist the action of the current at those periods when it would be most rapid, namely during equinoctial high tides with a stiff breeze from the south. The waters of the Red Sea being brought into the Bitter Lakes would fill them up, and form an inland sea in which the bed of the canal excavated to a proper depth as it enters and leaves the lakes, would merely be marked by buoys; and in this way the vast expanse of the Bitter Lakes would be covered, their total diameter being no less than 23 kilomètres (14½ miles), deducting the canal works at each entrance.

We feel persuaded that this system which is the simplest, is also the best, and we dispense accordingly with all embankments. But nevertheless, although our conviction is thoroughly established, we think it prudent to anticipate the contingency, of which on the other hand there is little probability, of embankments being eventually found indispensable. We are of opinion therefore, that the line of the canal while it is left without banks on either side, should be traced in such a direction across the Bitter Lakes that it would be easy, if subsequently required, to make not two embankments, but one only which would of course be on the windward side, in order to protect the canal against storms from the W. or N.W. The channel will therefore be transferred a little towards the eastern part of the lakes; and it will devolve upon the engineers charged with the execution of the works to select such inclinations as may seem best suited to favor this construction, should it ever be deemed advisable.

In this system, which seems to satisfy present requirements, while it leaves a margin for future contingencies, and which therefore we do not hesitate to propose, every thing depends upon what the current may prove to be along the entire course of the canal. If the current, which is to enter from the Red Sea and extend as far as Pelusium, were to be sufficiently powerful to endanger the stability of the banks; if the canal were to require to be lined throughout the whole of its extent: we should have no hesitation in acknowledging the necessity for locks, by which alone the danger could be obviated. But such will not be the case.

The knowledge we possess of the relative levels of the two seas, and of the fluctuations to which those levels are subject under the influence of winds and tides, permits us to determine what will be the regimen of the waters in the canal; and the results of our calculations, which are annexed to the present report, have completely tranquillized all our anxieties. The highest degrees of velocity which the waters can attain along the bottom, and which can only be for a short space under the extremely rare combination of circumstances, produced by the coincidence of a gale from the south with the highest equinoctial tide, are as follow:—

1° If the canal be continuous from one sea to the other, the velocity will be 1^{m} 01 per second: (3 31 ft.)

2° If the canal be interrupted in its passage across the Bitter Lakes the velocity will be 1·16 mètres (3·80 ft.) in the section south of the lakes, where the soil is clay and 0·35 mètres (1·14 ft.) in the section north of the lakes, where the soil is sand.

Under the first system, the banks would be exposed to injury from the plateau of Suez to the Mediterranean, for an

extent of 140 kilomètres (87½ miles), through sand; and locks at each extremity of the canal would be indispensable. Under the second system the bank could only be endangered between the Red Sea and the plateau of Suez, and in those parts where the clay may not be compact. To dispense with the necessity for locks, nothing more would be needed therefore than to protect those few weak portions that may be met with in the first 20 kilomètres (12½ miles) of the canal.

The Engineers of H. H. the Viceroy had, in like manner, proposed in their project that the canal should be left unembanked in its course through the Bitter Lakes; we entirely concur with them on this point. Their motives were not based on the same grounds as ours, as they closed the canal at Suez with lock-gates; but they had concluded, after examining the ground, that leaving the passage across the Bitter Lakes open would not interfere with the navigation. They were even persuaded that this inland sea, larger than either the Lakes of Berri, or Thau in France, would present advantages of more than one description.

We will add our own opinion to the same effect, that this Inland Sea far from being a formidable feature, may render very important services, and furnish the company with productive fisheries to let out. The fresh water canal, which will pass at a short distance to the west of these lakes, taking the direction towards Suez, will offer facilities for erecting a number of establishments in these now deserted regions; and without allowing more freedom to the imagination than is befitting in matters of this kind, it may be anticipated that not only will a source of handsome revenue be here supplied; but incentives to progress in trade, agriculture, and industry, worthy of the most studious interest.

SECTION IX.

DEPTH AND WIDTH OF THE CANAL.

THE authors of the project proposed to give a depth of 8 mètres (26 ft. 3 in.) to the canal, which they obtained by direct excavation down to 6.50 mètres (21 ft. 4 in.), and the remaining 1.50 mètres (4 ft. 11 in.), by the higher level they expected to secure from the action of the locks.

This depth is sufficient for the largest merchant vessels now navigating between Europe and the Indian Seas; say for instance, for clippers of 3,000 tons. We have not thought it necessary to add to it, since it will always be time enough to do so, when it shall be found necessary. Acting from this twofold consideration, we have without hesitation adopted the minimum depth of 8 mètres (26 ft. 3 in.)

The bed of the canal may besides be made to incline slightly from south to north, as the level of the Bitter Lakes will be maintained at $0^{m}.28$ (11 in.) above the mean level of the Red Sea, and 0.40 mètres (16 inches) above the mean level of the Mediterranean.

As regards the width of the canal, the general principle acted upon by the Commission is the following:—The canal

must be sufficiently wide not only to allow the passage of two lines of vessels; but to leave space for another line of ships, in case, through any reason they should be arrested in their progress. It is true that this emergency will be of very rare occurrence, as there will be an intermediate station for the loading or unloading of vessels. Two vessels, for instance, of 1,000 tons, to take an average example, placed abreast, would require only 40 mètres, (130 ft.) including paddle-boxes; and when screws only will be employed, the breadth of the vessels would be still less. A third vessel would require 20 mètres (65 ft.) more. In all 60 mètres (196 ft.) Let 20 mètres more be added, to allow free space for movement. We conceive, therefore, that 80 mètres (262 ft.) at the water line corresponding to 44 (144 ft.) at the bottom would be a sufficient breadth. The Caledonian canal is only 56 ft. across; and the breadth of the North Holland canal is 38 mètres (124 ft.). The difference, it will be seen, is considerably in favour of the projected canal. In the first place, however, there are locks in both these canals; whereas in ours there are none. Secondly, the purposes to be served by the Suez canal are altogether of a special character. The two canals to which we have alluded are in some sort purely local, and for internal communication. The Suez canal, on the other hand, is destined to afford a passage to a navigation in which the vessels may now be counted by thousands, and will increase to a still higher number. It demands, therefore, such dimensions and capabilities as constitute an exceptional case.

In all probability, recourse will not be had to ordinary steam tugs upon the canal, as there will be two towing chains, one upward, the other downward, by which the traffic will be regulated. The towing chain may be unin-

terrupted from Suez to Pelusium; and there would be a certainty of its being always kept in good repair, as each link as it passed over the windlass could be inspected. Any injuries might thus be soon discovered and repaired. As chain towage is very economical and sufficiently rapid, since it can do 6 kilomètres ($3\frac{3}{4}$ miles) going up, and 8 kilomètres (5 miles) going down; it is probable that it will be made much use of on the canal, and that very often two tiers of vessels will meet abreast, several being on the same chain both upward and downward. It might be settled even that tugs should never be employed, and recourse be had to the chain towing system only.

It stands to reason that passing places will be established at intervals along the canal. There are several existing already, formed in some sort by nature, such as the Bitter Lakes, Lake Timsah, and a part of Lake Menzaleh. Between Suez and the Bitter Lakes none will be required, as the breadth will be greater in that part than elsewhere.

We have before pointed out that this portion of the canal would require to be widened, from the fear of the abrasive effect of the current upon the banks, and because the latter were to be protected in certain parts by pitching. From the Red Sea to the Bitter Lakes, therefore, a distance of 20 kilomètres ($12\frac{1}{2}$ miles), the breadth of the canal at the water line will be 100 mèt. (339 ft.), answering to a breadth of 64 mètres (70 ft.) at the bottom; whereas throughout the remainder of its course the canal will present a uniform breadth of 80 mètres (263 ft.)

This makes a reduction of 20 mètres in the breadth proposed by the authors of the project. For a length of

127,000 mètres (79 miles), the saving thus effected is 20,000,000 of francs (£800,000). It was not the question of economy, however, that influenced our determination. But we are convinced that a canal 80 mètres in breadth, will be completely sufficient for a long period for all the requirements of long sea navigation.

Save and except the modifications just referred to, we adopt the section of the project. Accordingly, the slopes will be one mètre (3·28 ft.) in height, to a base of two mètres (6·54 ft.) Each slope will be surmounted by a "banquette," two metres broad, beginning one metre below the water-line. This banquette will have a rubble facing, which will extend along the whole course of the canal, and will be one mètre in breadth below, and 0·50 mètres above. This rubble work, which will be made of small materials, is for the purpose of preserving the banks from the chopping of the waves, and to prevent them from slipping down into the water from the action of the wind, or of the breakers. It is, moreover, an ascertained fact, that the chain-towing system which is to be applied to the canal, is found greatly to protect the banks, and to render any deterioration they may receive less rapid and less extensive. We have not considered it prudent, however, to dispense with the stone revetement and the banquettes.

SECTION X.

THE EMBOUCHURE OF THE CANAL IN THE RED SEA AND THE MEDITERRANEAN.

We now approach the most delicate portion of the project, namely, that which regards the two Embouchures of thecanal; that to the South in the Red Sea, and that to the North in the Mediterranean.

We will commence with the roadstead of Suez, where the works will be less extensive.

THE PORT OF SUEZ.

We adopt the direction given to the channel in the Gulf of Suez, by the authors of the project, and with them, we have no hesitation in carrying it out to the East of the roadstead. The track eastward is shorter and less costly, It fixes the entrance into the harbour in part of the roadstead where the shore is steep and the bottom clear. The channel running N.W. and S.W. is sheltered from the sea in the offing; and vessels can enter or leave with sails set by the prevailing winds from the N.N.W. The

choice of the situation, and direction of the channel, is well founded. Unimpeachable, however, as are the general features of the project in this respect, there are some details in it which require modification.

The inner basin, conceived with a view to facilitating the entrance of the tide into the canal, and to afford the means of occasionally scouring the outer harbour, is not requisite. The dyking of the channel between Suez and the steep bank which forms the outer barrier of the roadstead is a superfluous precaution which circumstances do not justify; that portion of the channel which is to be excavated in the open sea being evidently the only one requiring the protection of jetties. In the project the length of the jetties is laid down at 4,000 mètres (4,374 yards, or 2½ miles,) and they reach that part of the roadstead in which the large steam vessels of the Peninsular and Oriental Company be at anchor. This arrangement, by which the best portion of the roadstead is cut in half would make it dangerous for vessels laying-to there, before entering the channel, especially if they should arrive in the night. Lastly, the breadth of the channel, restricted to 100 mètres (109 yards,) in the project appears insufficient to provide for the easy entrance and departure of vessels.

The roadstead of Suez is spacious and safe. It is capable of accommodating 500 vessels of the larger size. It has a depth of water varying from 5 to 13 mètres (16 to 42 ft.,) the bottom being soft mud, and affording an excellent hold. These points, established by the French engineers, in 1799, and by Rear-Admiral Gantheaume, were confirmed by the experience of our colleagues. In the minutes of their proceedings in Egypt a remarkable fact is brought

forward, which we will repeat here, as it proves the goodness of the anchorage in the Suez roads. The English corvette Zenobia, serving as a coal-tender for the steamers of the Peninsular and Oriental Company, has been stationed there for three years without her anchors having dragged, or her communication with the shore having been interrupted for a single day. This fact, which was asserted by the Captain, and borne out by the entries in the log-book, is confirmed by the experience of vessels frequenting Suez. There are few roadsteads in the world presenting similar conditions of safety. Two deep and clear passes, wide enough to allow of tacking, open out into the sea, on either side of a bank of rock, through soundings of from 16 to 17 mètres, (52½ ft. to 55¾ ft.) and allow of entering and leaving the roadstead in all weathers. To the south-east of this bank the bight formed by the point of Attaka (Ras el Adabieh,) presents another anchorage of equal extent, and on a rank with the former for safety.

The roadstead of Suez possesses, therefore, all the desirable qualities for forming the entry to the canal joining the two seas.

The N.N.W. wind, which prevails almost continually, and is the most violent wind that blows, is not of a dangerous character. The S.S.E. wind, blowing from the offing, and the only one that could cause a heavy swell in the roadstead, is not generally very violent, and never lasts more than three, or four days together. The waves to which it gives rise scarcely run higher in the anchorage than those which are occasioned by the land winds when they are violent.

The observations made in 1856 on the tides at Suez, and

the statements furnished by the Harbour Master as to the highest levels reached by the sea within the last 20 years, supply sufficient data for the exact determination of the main level of the waters, and the fluctuations of that level, according to the influence of the tide and winds.

The ordinary mean level of the Red Sea at Suez is 1.64 mètres (5 ft. 4 in.) below the upper tablet of the quay, to the right of the Hotel stairs. It rises 0.61 mètre (2 ft.) during a gale from the south; and falls 0.56 mètre (1 ft. 10 in.) during a gale from the north. The tide rises and falls above and below the mean level a maximum height of 1.05 (3 ft. 4 in.); and an average height of 0.80 (2 ft. 7 in.) in the flood season, and 0.40 (1 ft. 3½ in.) in the season of low levels.

The currents in the Bay of Suez are feeble; they do not follow the outline of the roadstead, but run alternately to the North and to the South, and turn every where at the same moment. When the canal is established, the reciprocal balancing of the waters in the roadstead and in the Bitter Lakes will accelerate to a marked degree, the rapidity of the currents towards the entrance of the channel. According to calculations made by us, the velocity along the bottom between Suez and the Bitter Lakes may, under exceptional conditions, attain the rate of 1.16 mètre (3 ft. 9½ in.) per second during flood tide; and 0.97 mètre (3 ft. 2 in.) during ebb.

The Red Sea has no streams running into it; the shores, generally composed of hard rock, oppose a resistance to the destructive action of the waves. The alluvium deposited is chiefly derived from the broken remains of shell-fish and mud refuse cast up by the sea and from the mud

and shingle swept down to the shore by the heavy rains, which are rare in this climate, but always of a deluge-like character.

The shore enclosing the roadstead consists of sandy beaches, the configuration and extent of which appear to be permanently fixed. These beaches extend under the sea to depths of from 4 to 5 mètres (13 to 16 feet). Beyond this the bottom is covered with soft mud, mixed with broken shells, and does not appear to have been perceptibly raised in height during a lapse of centuries. The firm hold afforded to anchors, and the unvarying limpidity of the waters in the roads are a sufficient evidence, that the bottom is subject to little, or no commotion, in rough weather.

The deposits of sand and mud, forming the inclosure, and extending over the bottom of the Suez roads not being subject to any augmentation, or shifting only to an imperceptible degree, there can be no fear of the channel, or the harbour silting up from alluvial deposits.

With so favourable a state of things before them, the Naval Officers forming part of the Commission would have wished that jetties could be dispensed with and that a channel should simply be excavated and maintained at a proper depth by dredging as far as the anchorage. This desire had already been expressed in Egypt by one of our colleagues, and, upon an inspection of the locality, he imagined that the banks formed of the sand dug out to form the channel would be sufficient to maintain it. The firmness of the deposits of sand and their tendency to harden into stone appeared to him sufficiently to warrant this course. It being objected by the other members of the Commission that these embankments, formed merely of the stuff dug from the bed

of the channel, would crumble down into it when acted on by a heavy sea or by the tidal currents: he proposed an extensive dredging of the roadstead in the vicinity of the beach.

These different proposals, completely doing away with jetties, have not appeared to us acceptable. We believe that the natural slope of the bottom in the vicinity of the beach is one of the conditions of its stability; and that any pass affording a draught of water of eight mètres (26 feet), opened up by dredging between the port of Suez and the roadstead, would occasion within the zone, upon which the waves now break, extensive movements of sand, which would make the channel deviate to the right, or to the left, and would, in spite of incessant dredging, render the passage uncertain and precarious. This invariably occurs, wherever the balance between the waters of the sea and of those of lagoons, establishes itself across an extent of beach; as is notably the case at the "*graux*," in the Gulf of Lyons, the "*boccas*" of the Adriatic, and the "*boghazes*" of the Gulf of Pelusium. Whenever it has been sought to maintain an opening into the lagoons, it has been found necessary to inclose such cuttings within jetties, in order to keep them fixed, and to deepen them by bringing the currents to act on the same parts. It is true, that the waves, at Suez, are less violent than along the shores of the Mediterranean; but as the channel would require to be of a greater depth, the difficulty of maintaining it would be equally great. There would be no other chance of rendering it fixed, than by dyking it through the zone of the breakers, and as far out as where the bottom ceases to be disturbed by heavy seas.

We have, therefore, decided upon a mixed system, which consists in dyking the channel with stone banks as far as

six mètres (19½ feet) soundings and joining it on, by means of an excavation 500 mètres (541 yards) in breadth, with that part of the roadstead in which a depth of from 8 to 9 mètres (26 to 29½ feet) is naturally obtained. This middle term, between a dyked channel from Suez out to 9 mètres (29½ feet) soundings, and a channel without dykes, combines the advantages of both systems without the inconveniencies of either. It cannot, in the present case, be alleged that jetties, stopping short at a depth of 6 mètres (19½ feet) would cut the anchorage in two; as those parts of the roadstead which do not present this depth of water are useless to the larger class of shipping. Nor can there any longer exist apprehensions as to the deviation, or filling up of the channel, as it would be dyked wherever the waves could stir up the bottom. Such a channel would very probably be maintained at a proper depth, by the sole action of the tidal currents and most certainly so with the help of occasional dredging.

The western jetty will be 1,800 mètres (1,968½ yards) in length, and the eastern 2,000 (2,187 yards, or 1¼ mile). They will be parallel, and their direction N. 30° E. and S. 30° O.; so as to allow vessels to enter and stand out by S.E. and N.E. winds, which are those almost exclusively prevailing in the roads. The dyked canal will be 30 mètres (32½ yards) in breadth; and its prolongation from the head of the jetties to 9 mètres sounding (29½ feet) will be 500 mètres (546 yards). As this channel opens into a roadstead where the sea is never rough, and the wind is almost always available, these dimensions are amply sufficient for securing facility of entrance and departure.

The crown of the jetties would be 3·64 mètres (12 ft.)

above the ordinary mean level of the Red Sea, and 2 mètres (6½ ft.) above the quay at Suez; that is to say, above the highest level. The slope of the inner side would be at an angle of 45 degrees, and that of the outer side would be one of base to two in height. Rough blocks of stone would be employed.

In the western jetty the block of masonry would have a breadth of 7·80 mètres (28½ ft.) at the base, and 6 mètres (19½ ft.) at the crown. It would rest upon a bed of concrete 1 mètre (3¼ ft.) in thickness. The depth to which the block would be imbedded would be 1 mètre on either side. The parapet would be 0·80 mètre (2½ ft.) in height and breadth.

The dimensions of the western jetty would be on a smaller scale. The block of masonry would only be 5 mètres (16 ft.) broad at the base, and 4 mètres (13 ft.) at the crown. The depth of imbedding would be the same.

The heads of the jetties would be 25 mètres (32 ft.) long by 12 (39 ft.) broad, for the western, and 20 (65 ft.) by 10 (32 ft. 7 in.) for that in the eastern side. Both would be raised 2 mètres (6½ ft.) above the platform of the jetties.

We have judged it expedient to add to these works an inner basin, which requires no justification as to its utility in a harbour which will be resorted to by thousands of vessels. In front of the present quay at Suez, therefore, a basin will be constructed surrounded by quays, which will be extended according to the additional requirements of the traffic. For the present we propose only to establish a quay 800 mètres (875 yds.) long, and a basin 200 mètres (218¾ yds.) extending the whole length of the quay. The solid masonry

forming the quay walls would be 2 mètres (6 ft. 6 in.) thick at the base, and 1 mètre (3 ft. 3 in.) at the summit, which would be on a level with the present quay. It would be imbedded to a depth of 0·57 mètre (1 ft. 10 in.) on the inner side, and 0·46 mètre (1 ft. 6 in.) on the outer face. The bed of concrete would be 4 mètres deep (13 ft.) by 2·50 mètres (8 ft.) with a revêtement 0.22 mètre (8½ in.) towards the sea, and 0·11 (4 in.) on the inner side. The depth of imbedding for the blocks will be 1 mètre (3 ft. 3 in.) for both sides.

The materials for these constructions will be derived from the quarries of Attaka, a mountain in the vicinity of Suez; and for certain portions of the work from those of Mount Salem, on the other side of the roadstead in Asia, a short distance to the east. The rubble-work would be executed in calcareous stones from Attaka. The masonry for the crown and the parapet would be in free stone, from the quarries of Mount Salem. The materials supplied by the quarries of Attaka will be excellent for the purposes of the works. This mountain, which is extremely abrupt on the side towards Suez, is formed of a compact lime-stone, presenting very extraordinary indications of change. The surface itself is not subject to decomposition but appears only to have undergone a species of torrefaction, which has affected its appearance rather than its actual nature. It is beneath this outer crust that the change takes place. The phenomenon, however, is not observable in every case. In the narrow gorges, down which, during storm-showers, torrents issue forth sweeping along masses of substance, the rock kept continually bare by their friction has preserved an entirely different appearance. It is extremely hard, and appears to belong to the same formation which

furnished the stones used in the construction of the Pyramids and which were quarried in the neighbourhood of Cairo, on the right bank of the Nile. They exhibit on their surface numerous fissures, but these fissures are found on examination to be rather apparent than real and are not to be traced in the interior of the mass. This species of lime-stone may therefore be very usefully employed in the works.

PORT SAID ON THE MEDITERRANEAN.

It has already been stated above, in speaking generally of the track proposed, that we have transferred the embouchure of the canal in the Mediterranean 28½ kilomètres (17¾ miles) further to the west than in the project. The details into which we are now about to enter will explain the reason for this decision, and may perhaps disseminate more accurate notions as to these latitudes, which have hitherto been very imperfectly known.

The Gulf of Pelusium extends from Damietta point on the west, to Cape Casius on the East. It measures 75 miles across the opening, and 14 in depth, and faces the N.N.E. The gulf may be divided into two smaller bays, separated by a convex portion of the shore which advances into the sea. The eastern bay is the bay of Pelusium, properly so called; and the western bay that of Dibeh.

The beach throughout the entire gulf is formed of fine grey sand, without any admixture of mud. It is composed of a narrow littoral belt, or *lido*, about from 100 to 150

mètres (109 to 164 yards) in breadth. It could hardly have been less than this at any period. The height of this *lido* above low-water mark is, for the most part, not more than 1·5 mètre (4 ft. 11 in.). It is not washed over by the waves in ordinary weather; for at this point of the coast they never attain any great height, owing to the feeble declivity of the bottom extending under the sea. Behind this belt, which in rough weather is in some parts washed over by the sea, stretching eastwards towards Cape Casius, stands a row of *dunes*, or sand hills, upon which grow a few plants, and which may therefore be considered as fixed. In the centre, round Pelusium, is the muddy bed of the dried up part of Lake Menzaleh, and westward again is the present Lake Menzaleh, extending 10 or 12 leagues (25 to 30 miles), as far as Damietta. This lake is filled in part by the waters of the sea, which find their way in through the *boghazes*, and sometimes over the *lido*.

The *boghazes* are natural cuts across the beach, formed by the ancient mouths of the Nile and through which, at the flood time of that river the overflow of Lake Menzaleh pours out into the sea. The balancing of the waters of the sea and those of Lake Menzaleh; the level of which is essentially variable, produces through these mouths alternating currents of considerable velocity, by which they are kept perpetually open. These natural cuts across the beach, proceeding from east to west, are:—

1°. The embouchure of the ancient Pelusiac branch, which is called the Tineh mouth, on account of an ancient fort situated upon this branch.

2°. The embouchure of the ancient Tanitic, or Saïdian

branch, now called the Oum Fareg mouth, near the tower so called, built by the French during the Egyptian expedition.

3°. And, lastly, the Ghemileh mouth, establishing a communication between the sea and Lake Menzaleh. The Ghemileh, or Ghemil mouth is 385 mètres (421 yards) broad, and of variable depth, being about 1 mètre (3 ft. 3 in.) at low water. This mouth, or boghaz has had a tendency to widen since the Dibeh mouth, situated more to the W., has been obstructed. The Dibeh mouth is the ancient Mendesian branch.

The point of Damietta is gaining on the sea, whereas Cape Casius presents unmistakeable traces of wearing away. The salient portion of the shore between the two bays of Dibeh and Pelusium, is undergoing a similar process of erosion. The littoral belt at this point is very narrow, and rests upon a deposit of Nile sediment formed at some bygone period in Lake Menzaleh; the shore must therefore have receded.

As respects the shore at Pelusium, it certainly has not perceptibly varied within the last twenty centuries. The ruins of the town so called are, at the present day, at the same distance from the sea as in the time of Strabo; and the dried-up muddy deposits of Lake Menzaleh are only divided from them by a narrow belt of sand, which cannot have greatly increased in breadth, as it does not exceed 100 or 150 mètres (109 to 164 ft.).

The shores of the Gulf of Pelusium have not perceptibly varied in form, or position, therefore, within the memory of man. The additions and losses which occur on some

points are due to local causes, and their effect in the course of ages is all but *nil*. The littoral belt, from Damietta to Cape Casius, may, therefore be considered as permanently fixed.

Winds from the W.N.W. blow for two-thirds of the year, and prevail principally in winter. It is from this quarter that storms arise, which on the coast of Egypt, however, are rare. N.N.E. winds are much less frequent and less violent. But in the Gulf of Pelusium, they are almost equally formidable, as they strike it in full. Easterly winds are extremely rare, and always very feeble. As regards those from the south, they likewise very rarely blow with any violence; and being land winds, they are not attended with danger. During fine weather, and principally in summer, solar breezes spring up in the gulf; they blow from the S E. and N.E., or S.W. and N.W., according as the prevailing wind is from the E. or the W. The permanence of these alternate land and sea breezes, blowing from the north during the day and from the south during the night, would facilitate the entrance and departure of vessels into and out of the canal.

The currents in the Gulf of Pelusium are only of inferior intensity. They vary with the wind and the amount of swell. When the sea is calm and the wind slack, the current sets from E.N.E. to W.S.W. Its velocity is at the rate of about two miles a day. To the South of the Gulf there exists another current, which is much more perceptible. This may be inferred from the course which vessels have to steer, when proceeding from Alexandria to the Syrian coast. The drift carries them southward, even when there is no wind from the offing; and, to make Beyrout and Alexandria,

they steer about a quarter north of the direct bearing. When making for Jaffa, they meet with a drift in the same direction, but much less powerful.

The general current of the Mediterranean, sweeping the coast on the right and left facing the sea, does not enter into the Gulf of Pelusium. It is diverted towards the open sea by the position of the coast towards Alexandria, and by the flow of fresh water issuing from the mouth of the Nile. It is only perceptible in the vicinity of advanced headlands; where its velocity per second is from 2 to 4 decimètres at the utmost (8 to 16 inches).

Thus, then, in the Gulf of Pelusium the currents, during fine weather, are very feeble in their action and essentially irregular. They are produced by the back water from the general current passing outside, by the action of the prevailing wind, or by the fresh water flowing out of Lake Menzaleh. When the sea runs high and is swollen by violent and continuous winds from the south, the current bears toward the coast at the entrance of the Gulf. It accumulates masses of water within the Gulf, which run off along the shore in the direction of the prevailing wind. This accidental littoral current, carrying along, in suspension, the sand which the force of each wave has detached from the bottom, bears therefore sometimes to the West and sometimes to the East, according to the wind; and consequently in the majority of times to the East.

The general result of the eight surveys made of the Isthmus since 1846, has established the habitual mean level of the waters in the Gulf of Pelusium at 2.32 mètres (7ft. 7in.) below the datum line on the quay at Suez; and consequently

0.68 mètre (2 ft. 3 in.) below the ordinary mean level of the Red Sea. According to observations made of the tides at Tineh in 1847, and at Alexandria in 1856, the mean level of the Mediterranean on the Egyptian coast is raised 0.34 mètre (13 inches) during a gale from the North; and falls 0.32 mètre (12½ inches) during a gale from the South. The maximum rise and fall of the tide is 0.22 mètre (8½ inches); and the mean 0.09 mètre (3½ inches) in the quartiles, and 0.18 mètre (7 inches) in the syzygies.

Such is the general configuration of the Gulf of Pelusium; and the regimen of its waters under the influence of winds and currents.

As regards the bottom, its general character may be described as follows, according to numerous and accurate soundings taken by M. Larousse, a hydrographical engineer of the French navy, under the direction of M. Lieussou. It is perfectly true that at Pelusium, or rather opposite the ruins of Pelusium, at the spot where the Authors of the project had fixed the embouchure of the canal, a depth of 8 mètres (26 ft.) is only found at 7.500 mètres (8,200 yds.) from the shore, as may be easily imagined, that being the most concave portion. But, proceeding further west, this depth is gradually found to approach nearer to the *lido*. The slope of the bottom is everywhere very gradual, and tolerably regular. The line of the steepest fall occurs at a distance of about 18 kilomètres (11¼ miles) north-west of Oum Fareg. At this spot the contour line of 8 mètres depth is not more than 2.300 mètres (2,515 yds.) from the shore More to the west, towards Ghemil, the line continues at about the same distance from the land for a distance of 20 kilomètres (12½ miles).

These various circumstances appeared to us decisive of the question, and, on seeing their full bearing, it was impossible to hesitate in placing the embouchure of the canal at that salient portion of the coast, which is on a level with the ancient Saïs, and forms the limit of the bay of Pelusium, properly so called, to the east, and of the bay of Dibeh to the west. It is at this spot that the shore presents the greatest declivity; and it is here that there is the least cause for apprehension in regard to the rising of the bottom, as is proved by evident marks of erosion along the salient part of the shore.

In memory of the ancient Saïs, and at the same time in honour of the Prince who at present reigns over Egypt, we have given the name of Saïd to the port which we propose to establish in this region and which will merely be an enlargement of the embouchure of the canal.

At this point a depth of 10 mètres (32 ft. 10 in.) is met with, at 3,000 mètres (3,280 yds.) from the shore.

As regards the Gulf of Pelusium there remains one final question, which is the most important of all, namely, that of the deposit on, and the advance seaward of the shore. It has been imagined, that the continued existence of any sea-works undertaken in these quarters would be jeopardized by this cause. Naturally, this was a question to which our attention was directed with more than usual care and those of our colleagues who proceeded to Egypt have also devoted a peculiar degree of attention to the study of this question on the spot.

One fact is perfectly certain: no traces of mud are to be found along the shore and the sand upon it is as

pure as it is fine. This sand extends along the bottom without any admixture, to a depth ranging from 8 to 9 mètres, (26 to 29½ ft.). The mud does not commence until beyond this range and it is only at a depth of 10 mètres, (32 ft. 8 in.) that pure mud is found, and from thence it stretches out to an indefinite distance in the depths of the Mediterranean. Though here and there a few patches of mud may occur at a less depth, they are of insignificant dimensions, not exceeding 10 to 15 mètres (32 to 49 ft.) in diameter, and 0.25 to 0.40 mètre (10 to 15 in.) in thickness. Such deposits are recent and superficial, and have not been subjected to the effects of a storm; they are of purely accidental occurrence, and the first gale of wind from the north would entirely disperse them.

As the inclination of the bottom, though slight enough in the sandy zone, becomes still more so in that of mud, the large waves advancing from the open sea are gradually broken in force, and diminished in height. This explains why, about the approaches of the shore, the height of the waves, as has been before remarked, is, at the most, 2 mètres (6½ ft.) This fact, as was incidentally observed, affords a presumption in favour of the safety of the anchorage; it is a guarantee of the stability of any works which may be undertaken for the creation of a harbour in these quarters.

A second fact, no less certain than the former, is, that the Nile, as is the case with all large rivers having scarcely any fall towards their mouths, brings down to the sea a great deal of mud and very little sand. It is possible that in the higher portion of its course a different state of things may exist; but, in the *thalweg* of the lower part of its bed, only a small proportion of sand is found swallowed up, as it were, in

mud. When sand is found laid bare near the borders of a river on the banks, and the shore level with the stream, this is due to the action of the ripple producing a sort of washing and sifting of the alluvium. The mud is diffused in the water and borne away, while the sand, being heavier, is left behind, and in the course of time forms an accumulation. This constant separation of the sand from the mud may be observed still more plainly upon the bars in front of the *boghazes*. The continual agitation of the water preventing the earthy particles from being deposited, these bars are composed of pure sand; whereas, within their extent, where they afford a shelter, mud alone is found. These few sand banks, the formation of which is due to the continued action of the same causes for a succession of ages, do not militate against the fact, that the alluvium brought down to the sea by the Nile, and the nature of which is shown by the sediment which lines its bed, is exclusively of a muddy character.

The mud which the stream holds suspended in its waters, and the fine sand it rolls down along its bed, may be deposited mixed into a mass, in a calm sea, but the first gale that blows causes their separation.

The mud stirred up by the swell diffuses itself in the mass of waters and only settles down when the agitation has ceased. It is in this way carried to a distance, and in various directions, according to the currents at the bottom and on the surface, without being arrested by irregularities of the bottom, or by the indentations in the line of shore. On each occurrence of a heavy sea it is stirred up afresh, and eventually becomes lost in the great depths of the open sea and in Lake Menzaleh, where, no longer kept

in motion by the action of the waters, it settles down and forms a bed.

The sand which is thrown up by the swell subsides, until it is again disturbed by the same action. During the short time it is thus held in suspension, it partakes in the general movement of transference affecting the lower region of waters, and thus undergoes a series of minute displacements, which in the end become equivalent to a direct movement in the direction of the lower current. It is not diffused in the mass of waters in the same manner as the muddy sediment and its suspension is only an exceptional occurrence. It travels only at intervals along the bottom and its motion ceases as soon as the swell no longer disturbs it. It cannot, therefore, either be transported into the open sea, or be removed out of a bay, the horns of which stretch into great depths of water. It is retained near the shore in the region of shallow water, where the agitation does not allow the mud to settle and is constantly ridding it of the earthy deposit formed when the sea is calm.

In the Mediterranean the action of the waves is an indispensable, though not the sole, agent in transferring the moveable matter which forms its bottom. By washing up and diffusing the mud, by loosening and stirring up the sands, it merely prepares them for the action of the currents, which are too feeble to roll them unaided along the bottom. But in surging along the shallow bottom which it meets with opposite the shore, the waves become a direct and forcible agent in this transporting process. Each wave as it breaks, is accompanied by a retreating movement of the waters, bearing down with them the sand they have loosened, and imparting that to and fro movement which

is observed on a sea-beach. During this alternating movement the sand driven forward by the wave rolling directly in, glides down again with the surf, following the line of the steepest slope. It advances, therefore, up the beach by a succession of tacks, until it is thrown up beyond the reach of the waters. The fine sand, thus accumulated, is soon dried beneath a scorching sun and swept away by the wind, which scatters it over the plain, or heaps it up into *dunes*.

The incessant shifting backwards and forwards which the sand and mud, deposited in the first instance near the shore, undergo in the sea, amounts to a sort of sifting and sorting process by which they are eventually distributed according to their natural properties. The sand is confined to the shore, while the mud is carried out into the open sea. In this manner has the alluvium of the Nile, in process of time formed a zone of fine sand in the Gulf of Pelusium, which commencing at the beach terminates at a depth of 8 or 9 mètres (26 to 29½ ft.), and reposes on a bed of mud of indefinite extent.

A zone of from 2 to 3 kilomètres (1¼ to 1⅞ miles) in breadth, and averaging 4 to 5 metres (13 to 16 ft.) in thickness, a narrow beach and a few *dunes* scattered in its rear, represent the total mass of sand which the Nile has brought down into the sea ever since those remote times when it first made its way over the littoral belt.

The deposits of sand in the Gulf of Pelusium are, in point of fact, as ancient as the Nile itself. Their growth, in the course of ages, has not been to any perceptible extent.

As all mud deposits, whatever their magnitude, will, to the end of all time, be kept to the outside of the zone of sand, the shore line which can only become upraised by fresh deposits of sand may therefore be considered, when taken in the mass, as unchangeable. Any fresh deposits brought down by the Nile, form accumulations which are confined almost entirely to its embouchure; the projection of which into the sea augments to the extent of 3 or 4 mètres (10 to 13 ft.) every year. At all other points it keeps up the beach, but does not add to it.

According to this showing, therefore, the only objection to the direct track falls to the ground. To bring the canal out across the permanently-fixed beach of the Gulf of Pelusium is by no means an impossibility. Such a work would be easier of execution, than that of the port of Malamocco, created under much more unfavourable conditions, and to attain an object of far less importance.

We have fixed the outlet of the canal at 28½ kilomètres (17 miles 6½ furlongs) westward of the point adopted in the project: the shore being there less exposed to the prevailing winds, while it is steeper, and projects further towards the open sea. Further towards the N.W. in the bay of Dibeh and under the point of Damietta, a vessel could not right herself by a N.E. wind. Moreover the length of the canal would be uselessly extended. The projection formed by the shore opposite Saïd, between the bays of Pelusium and Dibeh, evidently offers the most favourable site; it will be easy to stand out, whatever wind is blowing, and a vessel caught suddenly in a gale of wind from the offing, at this part of the coast, can always right herself and get out into the open sea again.

It is true, that by transferring the embouchure from Pelusium, where it was contemplated to place it in the first instance, to Saïd, the length of the canal is increased by about 7 kilomètres (4 miles 3 furlongs). But this was not the consideration by which we were to be influenced, as, notwithstanding this extension, the advantages of the new site are such, that the total expense of this particular section of the works will be reduced by about one-half.

The Project comprised a mole situated in advance of the jetties at Pelusium. We are of opinion that this may be dispensed with; and indeed, the Authors of the Project had proposed it, rather as an additional precaution, than as a matter of necessity.

The local winds are extremely regular, and the anchorage on the coast of Egypt is better than any one to be found throughout the entire coast of Syria, which is directly exposed to the prevailing winds from the N.W., whereas the Egyptian coast is partially sheltered from them. The holding ground is everywhere excellent. M. Larousse, during his sojourn in the roadstead of the Bay of Pelusium, frequently observed the ship's position at intervals, and found no difference, although it had been blowing all night. If it were desired to bring a vessel to anchor previous to entering the canal, there would be no fear of her dragging her anchors. The native coasters declare that in rough weather they easily obtain shelter eastward of Damietta, in the very locality where the Canal is to terminate. It should, moreover, be remarked, that previous to the establishment of Austrian and French Companies for steam navigation, the coasting vessels engaged in what was called the caravan trade, on the coast of Egypt and Syria, frequently sought

shelter in the western part of the Gulf of Pelusium. This is sufficient proof that these coasts are far from being so formidable as they were imagined to be in the absence of any positive knowledge of the facts; and it may be taken for certain, that a vessel, sheltered from the W.N.W. winds, could keep her moorings with long cables during all weathers in water of 12 mètres (39 ft.) depth.

A breakwater 1,500 mètres (1,640 ft.), or even 1,600 mètres (1,750 ft.) long, situated at 1,000 mètres (1,093 ft.) from the jetties, would not only be of little advantage, but would be attended with two serious drawbacks, of which one is perfectly evident, while the other is extremely probable.

In the first place, when once constructed, such a work would unalterably fix the position of the harbour and if at a future period it should be found requisite to advance the jetties further out to sea, it would constitute a serious obstacle. There is no fear, as before stated, of any considerable deposits of sand at the base of the jetties, but if, (from the necessity of keeping the opening of the harbour beyond the zone of sand,) a prolongation should be subsequently required, it would be a source of regret that this could no longer be accomplished, and that the recourse to a safer and more costly expedient than dredging was cut off. On the other hand, the construction of jetties, separately, does not preclude the subsequent formation of a breakwater, should it become necessary, and the channel might at any time be sheltered by such means, should the experience of several years demonstrate the necessity of recurring to it.

In the second place, the littoral current passing through

the roadstead thus sheltered by an isolated breakwater, would deposit the muddy particles with which it is charged during bad weather. At present the muddy sediment remains in the great depths of the sea and is never found very near to the shore. But if a breakwater were established, it might perhaps accumulate within the space sheltered, and would occasion a result which should be avoided at any sacrifice,—namely, the shoaling up of the approaches to the channel formed by the jetties.

In a word, there is no necessity in this locality for a sheltered roadstead such as would be formed by a mole. The whole of the coast constitutes an open roadstead, with a safe anchorage in the offing, which would belong to every one, and in which a vessel might anchor for two, or three days, without paying any toll. The plan of a wide channel, opening freely into the sea, would allow of at once giving all the essential nautical qualities to the harbour of Saïd, and would provide for the future, by reserving the possibility of ulterior ameliorations and extensions. With a breadth of 400 mètres (438 yds.) a vessel might enter in all weathers, with the wind blowing full towards the offing and it will be sufficient to give the jetty on the weather side a peculiar form and direction, in order to obtain all the advantages of an isolated breakwater, without any of its inconveniences.

Port Saïd will, therefore, be left completely open, like that of Suez; or, rather, the embouchure of the Canal, with its two jetties, will be placed at Saïd, without any other works. It is proposed give it a breadth, however, of 400 mètres (438 yds.) instead of 100 mètres (109 yds.) as shewn in the project, the latter dimensions being evidently inadequate for a channel, where vessels should be able to place them-

selves athwart, a position they are sometimes obliged to take in coming to an anchor. A width of 400 mètres, which is only two cables-length, is indispensable for vessels to ride at anchor without coming in contact with the jetties; for they would be, in some sort, still at sea. Nor must it be forgotten, that some vessels will be 390 feet (120 mètres) long. Merchant vessels are no longer built only 130 feet long, as they used to be, the clippers of the present day being at least three times that length.

The western, or northern jetty would be 3,500 mètres (3,827 yds.) long, in order to reach a depth of 10 mètres (32 ft.) That on the eastern, or southern side would only be extended to a depth of 8·50 mètres (28 ft.) Its length would be 2,500 mètres (2,734 yds.) Their general direction will be from S.W. $\frac{1}{4}$ S. to N.E. $\frac{1}{4}$ N., and the extremity of one will be slightly deflected, so that the tangent of the two heads should lie exactly SS.W. and NN.E., and be exactly 1,000 mètres in length (1,093$\frac{1}{3}$ yds.)

By this means a sheltered roadstead, or outer port would be formed, embracing a superficies of 40 hectares (98 acres) perfectly sheltered from the N.W. winds which prevail along this coast and bring with them the greater part of the storms. Vessels will be enabled to enter in all weathers, which is the essential point; and there will, besides, be a sort of inner-road, formed by the roadstead between the jetties. The length of this roadstead will be 1,800 mètres (1,968$\frac{1}{3}$ yds.) measuring from the extremity of the southern jetty, by 400 mètres (437$\frac{1}{2}$ yds.) This would form an additional space of 72 hectares (177 acres 3 roods), in which vessels would find shelter and smooth water.

But the outer port and the roadstead, however spacious,

might be found insufficient. As the vessels passing through the canal must be very numerous, they will not arrive one by one, although the arrivals during eight months of the year would be very regular, owing to the constancy of the north winds; but when the wind is favourable, vessels will come in in small squadrons. On the other hand, the Company will have to maintain a fleet of steam-tugs, as also of dredging and other vessels, and it will be necessary to provide an inner basin, beyond the jetties, in which vessels may be stationed. This will be obtained by widening the channel at the starting point of the jetties, by means of recesses 200 mètres (219 yds.) deep on each side. The breadth of the inner basin, therefore, will be brought in this way to 800 mètres (874 yds.); the length will be the same, and the area enclosed will be 64 hectares (158 acres).

This inner basin will, at first, not be furnished with Quays, except on the western side; and it may, therefore, be enlarged to an indefinite extent on the eastern side, should such a measure, contrary to our anticipations, be found necessary.

Collectively, therefore, the Port of Saïd would embrace an area of 176 hectares (339 acres 1 rood).

The Canal will open into the midst of this inner basin with a breadth of 100 mètres (328 ft.), which a little further up will be reduced to 80 mètres (262 ft.), and the two sections will be joined together by curves of large radius.

The jetties will be formed of rough blocks. The one towards the west will have a slope of 45° on the inner side, and

3 base to 1 height, on an average, on the outer. We say on an average, because along the greater part of the jetty the slope will be 2 base to 1 height; but, at the heads, the slope will be 4 and 1. The inclination of the rubble-work at Cherbourg is considerable, being 9 base to 1 height; at Genoa it varies from 6 to 3 base to 1 height. At Cette it is as much as 5 to 1; as also at Holyhead. At Malamocco and Barcelona the slope is only 2 base to 1 height, and, in general, there will be no necessity for its being more at Pelusium. In the first place, the jetty will be connected with the shore, and, moreover, the inclination of the bottom is very slight, as has been shown. Under these conditions, the force of the waves is deadened, and they can never be dangerous.

The eastern jetty would have a slope of 45° also, on its inner side, but the external slope would average $2\frac{1}{2}$ base to 1 in height.

The quality of the masonry would necessarily differ in the two jetties, as one would shelter the other from the reigning winds, and the heavy seas.

For the western jetty, the block of masonry resting on a foundation of concrete embedded to a depth of one mètre (3 ft. 3 in.) as at Genoa, would be 2·50 mètres (7 ft. 2 in.) above the mean level of the Mediterranean. It would be 8 mètres (26 ft. 3 in.) across the base, but not more than 6 mètres, (19 ft. 8 in.) at the crown; the remaining 6 feet 7 inches being taken up by the width of the parapet, which would be 3 mètres (9 ft. 10 in.) The entire height of the masonry, therefore, including the parapet, would be 5·50 mètres (18 ft.) above the

mean level. The depth to which the rubble-work will be embedded will be 1 mètre (3 ft. 3 in.) on each side.

The dimensions of the eastern jetty will be less. The bed forming the foundation of the masonry remaining the same, the breadth of the solid mass would be 4·50 mètres (14 ft. 9 in.), at the base, and 4 mètres (13 ft.) at the crown. The height would be 2.50 mètres (8 ft. 2 in.) above the mean level, equivalent to more than 2 mètres above the high water-mark.

The head of the western jetty will be 50 mètres (54⅞ yds.) in length, by 20 mètres (21⅞ yds.) in breadth, within the parapet. These dimensions do not appear to be greater than is required. The jetty being very long, and the distance from the land being considerable, a somewhat extensive establishment will be necessary on the platform of the jetty-head for the beacon, the beacon keepers, the look-out men, the pilots, the mooring posts and other details of utility to ships entering, or leaving the Canal. The jetty-heads will be carried up to 4·50 mètres (14 ft. 9 in.) above the mean level, in order that they may be easily discernible from a great distance at sea.

The head of the eastern jetty would not require to be more than 20 mètres, (21⅞ yards) in length, by 10 mètres (32 ft. 6 in.)

Mooring posts will be set up at intervals of 100 mètres (109 yards) along each of the jetties.

The quay-walls of the inner basin will be formed as follows:—1st, of a mass of rough blocks 4 mètres (13 ft.)

high, with a slope of 45° on each side; 2ndly, a mass of concrete, 4 mètres (15 ft.) in height, by 2·50 mètres (8 ft. 2 in.) in breadth, resting on the rough blocks, embedded to a depth of 1 mètre, (3 ft. 3 in.) on each side, and encased between two rows of posts joined together by pile planking; 3rdly, of a wall of masonry 2 mètres (6½ ft.) high, with an average thickness of 1 mètre (3 ft. 3 in.). The platform of these quays would be 50 mètres (164 ft 6 in.) in breath.

The following, then, would be the complete works of the Port of Saïd:—Two jetties, one of which, on the western side, advancing further than the other, would be nearly a league (2½ miles) in length; a channel of 400 mètres (1,312 ft.) in breadth; and an inner basin of twice its length and breadth leading into the canal, and allowing vessels of the heaviest tonnage to enter and leave in all weathers.

We have no hesitation in according our assent to the proposition, that these works, established under the conditions we have just pointed out, will prove perfectly stable, and will run no risk of destruction. The entrance, carried out as far as the zone of mud, will, to all appearance, be safe from invasion by the sand; and what little may find its way in during the most tempestuous weather, can easily be removed by dredging. Nor is there any greater apprehension as regards the mud, as the turbid waters of the Mediterranean can never gain an entrance into the channel, except by driving back the permanent current flowing from the Red Sea.

There might be some fear, that the sand, stirred up along the beach by the swell and the littoral currents, would accu-

mulate on the external side of the dykes, and gradually advance till it reached the jetty-heads. But, in the first place, the circumstances already considered above prove that the quantity of sand borne along is very small, and before the sand could reach this distance, of 3,500 mètres (3,828 yds.) in front of the beach, and occasion at the head of the jetties any shoaling, requiring to be counteracted, a considerable time must elapse, which may not unfairly be computed by centuries.

Such an eventuality then presents no formidable prospect. In proof of this, we may call cite several well-known examples, existing at preset. We have only to observe what is taking place with respect to the jetties of Malamocco, situated in advance of the lagoons of Venice, and in a far less advantageous position than those of Port Saïd, in the Bay of Pelusium. Constructed in small masses of 1½ mètres (4 ft. 11 in.) at the utmost, they have, nevertheless, not altered their position in the slightest degree, their section has undergone no alteration, and all that has been required to be done, during a space of twelve years, has been to extend the rubble-work at the extremity of the western jetty, which projects 2,200 mètres into the open sea. The violence of the waves, in heavy seas, is very great and the rapid currents which prevail in the Gulf have only deepened the entrance of the channel. A bank of sand has formed to the left of the western jetty and at its commencement; whereas the depth has increased at its extremity. It is presumable, that a similar result will follow in the case of the Port of Saïd. Far from silting up, the roadway will be deepened at the jetty-heads by the natural action of the large waves from the open sea. A sand bank will form in like manner on the left of the western jetty and at its commencement, and a

very long interval must elapse. before the whole coast towards Dibeh can become silted up. Admitting, contrary to all the probabilities of the case, that the accumulation of sand, outside the jetties, should be as great as it is at Malamocco, it can be counteracted at little cost, either by dredging or by successive extensions of the jetties. We refer it, however, to the result of experience, to point out which of these two systems it will be preferable to adopt.

As there are no materials for building in the Bay of Pelusium, it will be our task to point cut, in a subsequent portion of this report, by what means they are to be procured. The total mass of the works will be considerable; but the sources are abundant and easily accessible by sea or through the canal.

We are persuaded that the port established at Saïd, under the conditions we have pointed out, will be fully adequate to all the requirements of the navigation. The harbour is, rendered complete by a natural roadstead of indefinite extent, sheltered from the reigning winds from the W.N.W., and in which the sea is never high and the holding is excellent. It is our opinion, that, with long cables, a vessel could pass the winter in the outer roadstead; and we have expressed a desire that the fact be placed beyond doubt by direct experiment, as has been done in the case of Suez, with respect to the Zenobia wintering in the roadstead there. To meet our wishes on this point, M. Ferdinand de Lesseps has requested his Highness the Viceroy to send an Egyptian corvette to the Gulf of Pelusium, to be stationed there during the whole of the ensuing winter.*

* See Captain Paligret's Report in the Appendix.

SECTION XI.

THE INLAND PORT OF TIMSAH.

THE works to be executed in Lake Timsah are naturally of less importance than those at Suez, or Saïd. Lake Timsah presents a surface of about 2,000 hectares (4,937½ acres), and offers by nature every facility for the construction of a port at about an equal distance from the two extremities of the Canal. The bed of the Lake is from 4 to 5 mètres (13 to 16 ft.) below the mean level of the Mediterranean; the waters of the Nile, reaching it during high floods through the Ouadee Toumilat.

This favourable disposition of the ground suggests the destination of Lake Timsah, which may become an Inland Port for revictualling, and for repairing vessels employed in long sea navigation, and the point of junction where the fluvial and purely local traffic would connect itself with that proceeding to India and China. One alone, of these two objects, will engage our attention at present, viz.:—the establishment of an Inland Port, through which the Canal will

pass, and become a portion of it. As to the second point we shall refer to it hereafter, when specially treating of the Irrigating Canals which constitute a branch of the concession to the Company.

It is clear, that the Inland Port of Timsah will, when the commerce of the world passes through the Suez Canal, assume a very wide development. On their return from long voyages to China or Australia, Calcutta or Java, vessels however soundly built, and however favoured in their passage, will have numberless requirements of every description. Even those coming from the Mediterranean, where they have every necessary provision, may find it convenient to complete their stores here, or to take in a fresh supply. Were it only for the opportunity it affords of taking in water, Lake Timsah would present a great advantage, as it would render it unnecessary to take in any large provision at departure. For coaling, it would offer still greater advantages: for there is every reason to anticipate, that a large number of the vessels, making use of the Canal, will be fitted with auxiliary screws, especially taking into consideration that several years must elapse before the Canal will be finished.

It is not, however, enough that vessels should find a convenient coaling and watering station at Timsah; there must also exist every facility for executing all the various repairs which long voyages always render requisite. It is not necessary to enumerate here all the different establishments that would be suitable for an Inland Port, such as is projected. The organization of the sespecial establishments will form one of the principal objects engaging the Company's attention,

But it may be stated generally, that the Port of Timsah will be designed for revictualling, repairing, and careening.

Quays, therefore, will be constructed for loading and unloading; and they will be of sufficient extent to obviate the necessity for the vessels being moored with their bows, or sterns towards the quay, as at Marseilles, but may lie with their full length alongside. We consider that 1,000 mètres (3,280 ft.) of quays will be sufficient to commence with.

The most important work to be constructed is that of a Careening Dock, which the higher level of the waters in the Wadee Canal would enable to be filled and emptied by the action of a lock-gate. This dock would require to be at least 120 mètres (394 ft.) long by 25 (82 ft.) broad, Vessels are now built of great length, and in a new port all reasonable possible augmentation of the present dimensions must be provided for Formerly the relative proportion of the bowsprit to the length of the ship was as 1 to 4; now it is as 1 to 7 or 8, and even 9 in some exceptional instances of vessels built in England. A Careening Dock of such dimensions as those we have assigned to it could contain two vessels of ordinary dimensions, the united length of which would not exceed (with their bowsprits struck) 120 mètres (394 ft.). It is not improbable, indeed, that as many as three vessels, of inferior size, might find room in this dock, and they would be disposed in it according to the importance and probable duration of the repairs they needed.*

With respect to any other establishments that might be

* Since the publication of this report, other and very simple means of raising vessels for the purposes of careening and repair have been introduced, and now being tried at the Victoria Docks, London. Advantage will, of course, be taken of this improvement.

constructed at Timsah, or in other places along the course of the Canal—such as workshops, description, store-houses, &c.—we purposely refrain from entering into these details, leaving them to the consideration of the Company whose interest it will be to create such establishments as soon as they may be made useful and profitable.

SECTION XII.

LIGHTING OF THE COASTS OF THE RED SEA AND MEDITERRANEAN.

It is felt that it would be useless to invite the commerce of the world to adopt the new Route it is desired to open to it, unless every means ordinarily in use for such purposes were employed to facilitate its access. Our attention has, therefore, been turned to the question of Lighting the Coasts both of the Mediterranean and of the Red Sea. The difficulties which present themselves along the shores of these two seas are very different in character, but both are equally deserving of consideration.

The authors of the project, proposed to erect two light-houses—one at Damietta Point, to mark the road-stead

of Pelusium, and the other at Raz Mohammed, on the Red Sea, at the point where that sea bifurcates. In addition to these, they proposed two beacons at the head of the jetties of Suez and Pelusium.

Those of our colleagues who went to Egypt have proposed the lighting of the entrance into the road of Suez by a floating beacon, and by a lighthouse; and that the port should be provided with a light—the reefs existing round the outer edge of the roadstead being, moreover, beaconed, or marked out with buoys. They proposed, in like manner, with respect to Port Saïd, that its approaches should be marked by a coast-light established at Damietta Point, and that the entrance to the harbour should be lighted by two beacons at the heads of the jetties.

These provisions are very good in themselves, and might be sufficient were we to take the Canal alone into consideration. But the object in view is not limited to the two entrances into the canal; it is at least equally, or even more important, that it should embrace the approaches to it from a considerable distance. By giving thus a wide scope to the question of lighting the approaches to the canal, we do not propose to point out every lighthouse and beacon that it might be necessary, or convenient to establish; but desire merely to lay down the principles which should be assumed as the basis of any studies of a comprehensive project for lighting the Red Sea and the vicinity of the Gulf of Pelusium. It is only comparatively recently that the coasts of Europe, bounding the territories of the wealthiest and most civilized nations, have been lighted in a manner suitable to the objects in view, and in many localities there still remains much improvement to be made in the existing

modes of lighting. On the Asiatic coast everything remains to be done, and it would be well if the European Powers employed the opportunities, afforded by their relations with the various local Governments, to urge some advance in this direction. On the other hand, we acknowledge that the Egyptian Government, in particular, has recently adopted very laudable measures towards this end. The necessary apparatus for a first-class light has been ordered from Europe, to be placed in the Gulf of Suez. The channels at Alexandria, which have lately been bouyed out with screw moorings, will soon also be marked by lights.

As regards our own share in advancing this object, the following are the general views to which we have been led and we recommend them equally to the consideration of the Company and of the Egyptian Government; and we may add, indeed, of the Ottoman Government, whose intervention in the matter may be of no less utility.

It is admitted now, as a general rule, that for adequately lighting a coast, the lights should be placed sufficiently close together, simultaneously, that a vessel in the offing may always perceive two. In the British Channel two lights can always be seen at the same time, and even as many as three may sometimes be distinguished. But on the African coast of the Mediterranean there are only a very few lights established. From Tripoli to Alexandria, for instance, not a single light occurs, and this is one reason why vessels avoid those dangerous latitudes. Commencing from Alexandria, where it is very necessary that the number of lights should be completed as far as Beyrouth, there is no lighting, and vessels steer as far as is possible from this coast. As regards

the Red Sea, there is a complete absence of lights: from the island of Perim at the entrance of the Gulf, up to its extremity at Suez, no lights of any description have ever been established.

If it be desired, that the latitudes of the Gulf of Pelusium should become frequented, it is not alone sufficient to establish a lighthouse at Damietta Point and Port Saïd: the coast must also be perfectly well lighted from the Marabout Point, at Alexandria, to a distance of 20 leagues (50 miles) eastward of Pelusium, and the lights must be discernible, with ease, from each other. On this condition, only, will mariners frequent this coast as readily as they do that of France and England. Too many precautions cannot be taken in dealing with a coast which lies so low as that of Egypt, and which vessels come upon suddenly, even in the broad day, without being able to make it out. The light-houses must also be made to serve as landmarks during the day, either by the peculiarity of their shape, or their colour. They should be distinguished from each other by points of difference which cannot admit of any mistakes. Their height should be such as would render them always visible from a great distance. They would thus form easily-distinguished landmarks, and their utility along this coast would be the greater, as, in making land, the only objects to be seen are tufts of trees, which are necessarily confounded with one another.

As regards the Red Sea, the light of the first order which the Egyptian Government is about to establish at Raz Mahab S.E. of the Suez roads, and the harbour lights which we propose should be established at the extremities of the jetties and at their commencement, will be sufficient for the Gulf

of Suez. But there are points in the Red Sea at its entrance, and at the bifurcation into the two gulfs, which will necessarily require to be lighted. The naval members of our body have especially directed our attention to two of these,—the island of Shadwan and the island of Jubal, where the anchorage is excellent. Raz Mohammed at the entrance of the Gulf of Suez, properly so called, we have already mentioned. To these we might add Djeddah, which, being situated about midway on the passage, and possessing a sheltered harbour, might not unfrequently be resorted to as a touching station. Lastly, at the entrance itself of the Red Sea, and of the Straits of Bab-el-Mandeb, may be mentioned the island of Perim, dividing the Straits into two channels, the widest of which, to the S. W., is only eleven miles across.

It is our belief that the Red Sea, lighted at these points, or at such others as might be judged more suitable, would become still more safely navigable than it is. Indeed, at present it is far from presenting all the dangers which have been attributed to it by over-lively imaginations. Our colleague, Captain Harris, who has performed the passage through the Red Sea seventy times backwards and forwards, has declared, without hesitation, that, with the exception of a few points, in the inner part of the Gulf of Suez, it is not more to be feared than the Mediterranean, or the Adriatic. On the other hand, the Peninsular and Oriental Company, which for more than sixteen years past has performed the India and China mail-service through the Red Sea, has not had to record in its experience a single disaster; its large steamers have been enabled, without interruption and without accident, to follow the deep and wide channel which this sea presents in its central portion. But, trusting to legitimate anticipations of the future, we are not

to look only to large steamers passing through the Arabian Gulf, nor have we merely to provide facilities for a rapid and continuous passage. It is necessary that all the merchant vessels, of whatever tonnage, which will traverse the Red Sea in great numbers, should find the navigation safe and easy, not only at the extremities, but also in the intermediate regions, and at every point of the coast where it would be possible, or advantageous to touch. The general lighting of the coast of the Red Sea would, therefore, be one of the first consequences of the construction of a canal across the Isthmus of Suez.

It is, however, unnecessary that we should enforce this point with any great urgency. The Egyptian Government has recently determined on the formation of a Steam Coasting Navigation Company on the Red Sea. As respects the special question with which we are now dealing, this enterprise must, beyond all argument, be attended with the most favourable results. The coasting trade cannot be carried forward profitably on any other conditions, than facilitating the access to every port and every important point of the coast. We may, therefore, repose our trust both in the interest of the Coast-Trading Company, (which will naturally provide for the safety of its steamers,) and in the attention of the Egyptian Government.

The Suez Company will form arrangements with the Governments of the States on the seaboard. A consideration which will simplify these negociations is that all these works being of such advantage to mariners, will be partly paid for by them and by the dues levied for lighting. This was the course taken by the East India Company in the Hooghly River. As that outlet from the Ganges is extremely

difficult of navigation, and it was not found practicable to erect a permanent lighthouse, the company stationed a corvette there, which throws up Bengal lights every quarter of an hour, and rockets every half hour, that vessels may steer their course by its position. The Company have, moreover, organised a corps of pilots, whose services, supplied with perfect regularity, are remunerated with very high salaries. The light established recently by the English Government in the Malacca Straits is also kept up at the expense of the traders. The Universal Suez Canal Company might follow so good an example at Bab-el-Mandeb, Raz Mohammed, Suez, or Saïd. In a short time, too, they might avail themselves of the services of the experienced pilots which the establishment of steam coast-navigation will not fail to create in the Mediterranean.

To sum up, then, as regards lighting the approaches to the canal at either extremity, what we ask for is, in a general manner, that the coasts of Egypt and those bordering on the Red Sea should be lighted in such a way as to preclude all danger to navigation.

SECTION XIII.

OF FERRIES ACROSS THE CANAL.

In addition to all the questions already treated, there is one more point which must not be forgotten, inferior as it may be in importance to the rest. We refer to the establishment of Ferries—a subject not embraced in the project, no doubt on account of the insignificant expense with which it would be attended, in comparison with the rest of the enterprise. We think it is proper to mention this point, in order that nothing that can be foreseen, in connexion with the execution of the works, should be omitted from consideration. There are four situations where, at present, ferries may be looked upon as indispensably necessary. In the first place, two will be required for the two roads passing near Lake Menzaleh, and leading from Egypt into Syria. These roads have long been used by the caravans and must be preserved by the establishment of ferries which can take them over with facility and without any great delay, or expenditure. From a similar consideration, a third ferry must be appointed to the North of the Gulf of Suez. The Grand Caravan proceeding to Mecca usually goes by this road. The majority of the pilgrims

who travel on foot take it, while the smaller number embark at Suez, in order to reach Djeddah by sea and return by the same route. It may be presumed, that when the Coast Navigation is regularly established in the Red Sea, the pilgrims will prefer the commodious steamers of the company to the land journey, which is always excessively toilsome under the conditions to which they are obliged to submit. Independently, however, of the caravan, which will never entirely abandon the land route, it is expedient that an easy and constant communication should exist between the town of Suez and Asia. Finally, we are of opinion that a fourth ferry should be established at Lake Timsah, which will become a populous centre, owing to the works to be established there. It will therefore be requisite, that ready means of communication between the opposite banks should be provided and the necessity for a ferry at this point may be anticipated.

The management of the crossing at these four ferries must be so arranged, as not to interfere in any way with the free circulation of vessels along the canal.

SECTION XIV.

THE ELECTRIC TELEGRAPH.

No mention is made, likewise, in the project of the establishment of an Electric Telegraph; doubtless, the engineers would have classed the cost of this accessory with the unforeseen expenditure. It seems to us, however, better to settle beforehand the cost of such an establishment, with which it would be impossible to dispense. The expense moreover would not be very considerable, and would not amount to more than 250 fr. per kilomètre (£16 per mile), including everything. To this must be added the cost for the communicating apparatus, amounting to about 500 fr. (£20) for each station. It is clear that this would be a remunerative outlay. An electric telegraph, laid down simultaneously with the construction of the Canal, would be of essential service to trade and navigation, independently of its utility to the administration of the company's affairs. Keeping these considerations in view, it may be asserted, with confidence, that the Electric Telegraph of the Suez Canal will soon have paid its expenses, both for maintenance and first establishment.

SECTION XV.

FRESH-WATER JUNCTION AND NAVIGATION CANAL.

THE canal derived from the Nile, and joining the Grand Maritime Canal, forms an essential portion of the project now engaging our attention.

It will be seen at the first glance that a Fresh-Water Canal is absolutely indispensable to the execution of the works for the Grand Maritime Canal. In the second place, a navigable canal like this will be of immense utility to Egypt, no less than to the company, by affording the means of irrigating a vast extent of land. Finally, it will connect the whole country, and the system of hydraulic works which intersect it in every direction, with the great stream of navigation passing backwards and forwards along the frontier from Suez to Saïd.

The International Commission cannot, therefore, but accord their approval to the principle of this canal, the construction of which is moreover laid down as one of the conditions on which the concession is granted to the Universal Company by his Highness the Viceroy, together with the two branches

which, commencing from Lake Timsah, will run, one northward, the other southward, parallel to the Canal uniting the two seas.

We are of opinion, moreover, in common with the Authors of the project, that the Junction Canal should have a section of sufficient dimensions to admit all boats and steamers navigating the Nile, in order that the inland navigation may converge from every part of Egypt to the port of Timsah, without occasioning the trouble of transhipment. The volume of water supplied to feed this canal would be sufficiently great to leave, (after deducing the loss by evaporation, filtration, and lockage,) a quantity of water capable of irrigating 100,000 feddans (155,000 acres) during the winter, and 60,000 feddans (93,000 acres) during the summer. The level of the waters in the canal must be maintained, at the height most favourable to the natural irrigation of the immense extent of land contained in the Isthmus, now left barren, after having been fruitful for so many centuries.

In order to comply with the conditions we have just laid down, the Authors of the project propose bringing the water from Kusr-el-Nil, a little above Boulack, at the mouth of the Kalidj Zafranieh, and to avail themselves of the course of the Kalidj, as far as the point where, to the North of Cairo, it mingles with the Kalidj Manieh, the ancient canal of Trajan and of Amrou. The Zafranieh Canal was dug in 1837, under Mehemet Ali, upon nearly the same scale of dimensions as those of the new canal, as far as Tell-el-Ioudieh. Beyond this point its dimensions are smaller as far as Belbeis. The junction canal would diverge from Kalidj, near Abouzabel, where the old school of medicine stood, and

would proceed from thence in a north-easterly direction as far as Ras el Wadee (the Head of the Valley, the Pithoum of the Bible,) which contains the remains of ancient canals, of which some use might be made. It is, properly speaking, from this point that the Wadee Toumilat commences. The expense of completing the line of canal, subsequently, as far as Timsah would be small, nature having already created a vast bed, through which the waters of the Nile are frequently conducted into the lake. On the up-stream side of the lock by which the canal will communicate with the lake, a watercourse for irrigating purposes would branch off to Suez, and a conduit would be laid down to Suez. The canal would be 28 mètres (82 ft.) long, by 2 mètres (6 ft. 6 in.) in depth at low level. The depth of the watercourse for irrigation would be 1·60 mètre (5 ft. 2 in.) in depth, and the width 20 mètres (65 ft. 6 in.) for the first third of its extent; 15 mètres (49 ft.) for the second; and 10 mètres (32 ft. 9 in.) for the third. Such is the plan of the Viceroy's Engineers.

It might be considered at first sight better to make use of the Zagazig canal, which extends directly from that town, the ancient Bubastes, to the head of the Wadee. The construction of the alimentary canal would then be much more simple, and it would run in a straight line nearly from west to east between Zagazig and Timsah. In order to insure its supply, at all periods of the year, the bottom would be made two mètres (6 ft. 6 in.) below the line of low water in the Nile. Under these conditions, which are those of all the irrigation canals, precautions would have to be taken in order to preserve the normal section of the canal, and to prevent it from silting up at the point of junction with the river.

The authors of the project have rejected this system, basing their decision on the facts of the case and their long experience of the country.

It appeared to them impossible to maintain in proper repair a canal, the bottom of which was below the line of low-water in the Nile, otherwise than by an enormous expenditure; and even if incurring this cost, it was uncertain whether the desired result would be obtained. In all cases where an attempt has been to dig a canal below the low-water level, and more especially on the outskirts of the desert, in the Ghattat-Bey for instance, it invariably happens that at about the level of low-water, a bed of loose sand is met with, as was the case at Masteroud on the Zafranieh. This constitutes an enormous difficulty and a source of expense of which it is hardly possible to form any previous estimate. When even it is not sought to obtain any great depth below the level, 0·50 mètre, (1 ft. 7½ in.) for instance, annual dredgings of a really formidable nature are required. Thus in the Ghattat Bey, the labour of 30,000 or 40,000 men is required for the space of a month to clean out the feeder at the point of junction; in the Chibin, from 20,000 to 30,000 men are employed, and from 15,000 to 20,000 men for the Cherconieh. In the case of the Moëze, all attempt to dredge it has been given up. To justify the withdrawal of so considerable a number of hands from the ordinary employments of agriculture, nothing short of absolute necessity can be admitted—a great damage to the resources of the country is thus occasioned, and so serious a result should, if possible, be avoided. Indeed, the barrage of the Nile was constructed by Mehemet Ali on the supposition that it would be connected with canals situated at a height of two mètres above the low-water level.

Generally speaking, and setting aside special cases, the system of low irrigation canals, that is to say, of canals lying below the level of low-water, has now been abandoned in Egypt.

If the canal were dug to a depth of two mètres below the level of low water, as would be necessary in the proposed line, Zagazig being situated about 7 mètres (22 ft. 9 in.) above Suez, the first reach of the canal, 34 kilomètres (21½ miles) long, would be silted up every year, with an accumulation of 225,000 cubic mètres (294,394½ cubic yards) of sand. On the calculation that one dredging-machine can remove 500 cubic metres (654 cubic yards) per diem, it would require eight dredging-machines working for about two months to clear it out. During this period, the navigation, if not altogether interrupted, would be greatly impeded. Should any neglect occur in the discharge of this continually-recurring labour, the Mahmoudieh Canal furnishes an instance of the obstruction to navigation which would ensue, and the amount of labour required (not to speak of the inevitable interruption to the traffic) to clear out a canal thus obstructed with silt. It is true that, on the occasion when it was last repaired (last April) the bottom of the Mahmoudieh was brought down below the low-water level, but being destined to supply water to Alexandria, this canal is placed under altogether exceptional conditions; and, in view of the important services it is intended to render, no sacrifice was thought too great.

To these considerations, the Engineers of his Highness the Viceroy have added others.

In establishing the feeder at Zagazig, it would be requisite to add considerably to the depth of the locks as they now

exist. Seven bridges which now span the first reach would have to be demolished, as the aprons of all of them are situated at the low-water level. It would even be necessary to enlarge the present canal, which would be made 2 mètres (6 ft. 6 in.) deeper. Nor would these changes, naturally attended as they would be with difficulty and expense, constitute all that was required. It would be necessary to keep up the waters of the Nile to the head of the canal, by means of a weir, and this would induce a very dangerous scouring action, as is proved by what occurred at Benha, when Abbas Pacha, the predecessor of his Highness Mohammed Saïd, sought to divert the waters of the river by works of this description.

On the other hand, it would be easy to render available the course of the Khalidj Zafranieh, which, throughout the entire portion made use of, is not employed for the irrigation of lands. This is not the case as regards the canal of Zagazig, in dealing with which the double difficulty would arise of having to treat with the holders of adjoining lands, for those portions which it would be necessary to take, and also for the supply of water for irrigation, which would have to be insured to them. In Egypt, there is no law authorising expropriation for the public benefit, and the negociations with the holders of the soil would be attended with endless litigation The water with which they would have to be supplied, moreover, would greatly reduce the quantity which the Company itself would require for its own lands.

In addition to this, Cairo, the capital of Egypt, a city containing 300,000 inhabitants, would not be in any direct communication with the Ship Canal, a defect which would

be a great disadvantage not only to Cairo, but it may even be said to the whole country, since all the merchandise conveyed by the Nile, whether up, or down the stream, would be subjected to delays.

Lastly, the Egyptian Government having undertaken, under penalty, to execute the Junction and Irrigating Canal in accordance with the estimates laid down in the project, it is far from probable that, in the place of this project, it would consent to undertake another work, undoubtedly a more costly one, together with all the works of art which its execution would entail.

Several of these considerations, and especially the last, have decided the Commission, and they have referred the details of the Junction Canal to the Engineers, to whom its execution will be entrusted.

Independently of the connexion which the Junction and Irrigating Canal will establish between Egypt and the Ship Canal, and the services it will render during the progress of the works, it is impossible to overlook the immense advantages which will accrue from the cultivation of the adjoining land. But for the results of this cultivation, the Ship Canal would for ever remain in the midst of a desert. The fresh provisions, which will be so necessary for the ships on their passage, would be more difficult to procure, and would have to be brought from great distances at a considerable cost; whereas, on the contrary, when the adjoining lands are cultivated, there would spring up, from the midst of the present barren regions, an industrious population, by whom all the resources of a fertile country could be devoted to supplies for the ships. Nor is there any cause to

fear, that in anticipating such a result in the future, we are indulging in an over-flattering illusion. The whole of this country is, even to this day, teeming with numerous and unmistakeable traces of its former habitation by man. The Bible likewise testifies to the great historical events of which it was the scene. To restore these regions to their former fertility, nothing more is required than to bring back to them once more the waters to which they owed their former fruitfulness and of which they have been deprived only by neglect or political events.

REPORT—PART II.

SECTION XVI.

DETAILS OF THE TRACK.

We have already stated the motives by which we were influenced, in introducing certain modifications in the project, and how, while adopting it as regards a great portion of the course, we were induced to deflect the Canal from the original line 28½ kilomètres (17 miles 6½ furlongs) westward, for the establishment of the embouchure in the Mediterranean. We propose to give here a complete table of the lines and curves composing this track.

The direction of the two entrances at Suez and at Saïd, as we have described them, will be transversely to the direction of the prevailing winds. They will be broad enough to allow of all the necessary evolutions being easily performed by vessels, even of the largest size. The sharpest curve throughout the entire line of the Canal will be to the South, in the portion of the ground preceding the Bitter Lakes. Following a straight line from Suez, the course of the Canal will make a very decided bend at this spot. Subsequently it will cross the Bitter Lakes in a direct line, and, after making a few slight curves, it will resume a straight course at El Guisr, and will continue on it as far as Saïd. On account of the navigation it was necessary to avoid sinuosities, and to exclude all curves except those of large radius. This course we have been enabled to adopt, favoured by the natural formation of the soil, as the table opposite will show:—

Nos. of pegs.	Designation.	Length between each angle.	Length of the Tangents.	Length of Direct Line.	Length of Curves.	Radii.
	From the sea to the starting point of the first curve	3842·00 met. (4201·61 yds.)	.....	3242·30 met. (3545·78 yds.)	.....	.....
	Ditto ditto	.....	599·70 met. (655·83 yds.)	.....	.....	.....
12	Angle I., 169° 28′ 00″ (152° 21′ 3″, Engl.)	.....	.....	.....	1194·97 met. (1306·82 yds.)	6500 met. (7108.4 yds.)
	Ditto ditto	.....	599·70 met. (655·83 yds.)	.....	.....	.....
	Second main line.—From the head of the gulf to the smaller basin	24147·70 met. (26407·92 yds.)	.....	20180·00 met. (22063·85 yds.)	.....	.....
	Ditto ditto	.....	3368·00 met. (3683·24 yds.)	.....	.....	.....
74	Angle II., 138° 01′ 00″ (124° 12′ 32″)	.....	.....	.....	1491·45 met. (1631·05 yds.)	8500·00 met. (9295·60 yds.)
	Ditto ditto	.....	3368·00 met. (3683·24 yds.)	.....	.....	.....
	Third main line.—Within the smaller basin	8154·45 met. (8917·71 yds.)	.....	1491·45 met. (1631·05 yds.)	.....	.....
	Ditto ditto	.....	3295·00 met. (3603·42 yds.)	.....	.....	.....
94	Angle III., 147° 08′ 40″ (132° 22′ 32″)	.....	.....	.....	6018·04 met. (6581·33 yds.)	10500 met. (11482·80 yds.)
	Ditto ditto	.....	3295·00 met. (3603·42 yds.)	.....	.....	.....
	Fourth main line.—End of the smaller basin	7430·00 met. (8125·45 yds.)	.....	2084·00 met. (2279·06 yds.)	.....	.....
	Ditto ditto	.....	2051·00 met. (2242·47 yds.)	.....	.....	.....
113	Angle IV., 152° 45′ 00″ (137° 12′ 18″)	.....	.....	.....	3804·32 met. (4160·40 yds.)	9000 met. (9748·8 yds.)
	Ditto ditto	.....	2051·00 met. (2242·47 yds.)	.....	.....	.....
	Fifth main line.—Large basin	13044·35 met. (14265·30 yds.)	.....	8456·85 met. (9248·41 yds.)	.....	.....
	Ditto ditto	.....	2536·50 met. (2773·92 yds.)	.....	.....	.....
145	Angle V., 129° 04′ 20″ (116° 8′ 16″)	.....	.....	.....	4444·29 met. (4858·75 yds.)	5000 met. (5468 yds.)
	Ditto ditto	.....	2536·50 met. (2773·92 yds.)	.....	.....	.....
	Sixth main line.—Large basin	10999·50 met. (11996·24 yds.)	.....	5049·00 met. (5521·58 yds.)	.....	.....
	Ditto ditto	.....	3384·00 met. (3700·74 yds.)	.....	.....	.....
173	Angle VI., 149° 30′ 00″ (133° 28′ 12″)	.....	.....	.....	6597·36 met. (7214·87 yds.)	12000 met. (13127·2 yds.)
	Ditto ditto	.....	3384·00 met. (3700·74 yds.)	.....	.....	.....
	Seventh main line.—Cill of Serapeum	6379·50 met. (6976·62 yds.)	.....	995·20 met. (1077·42 yds.)	.....	.....
	Ditto ditto	.....	2010·30 met. (2198·46 yds.)	.....	.....	.....
189	Angle VII., 164° 44′ 00″ (147° 59′ 45″)	.....	.....	.....	3996·91 met. (4370·91 yds.)	15000 met. (16404 yds.)
	Ditto ditto	.....	2010·30 met. (2198·46 yds.)	.....	.....	.....
	Eighth main line.—Schiek Kmnédek	5790·30 met. (6332·27 yds.)	.....	1805·60 met. 1974·60 yds.)	.....	.....
	Ditto ditto	.....	1974·40 met. (2159·20 yds.)	.....	.....	.....
203	Angle VIII., 157° 40′ 00″ (141° 39′ 36″)	.....	.....	.....	3697·91 met. (4044·08 yds.)	10000 met. (10936 yds.)
	Ditto ditto	.....	1974·40 met. (2159·20 yds.)	.....	.....	.....
	Ninth main line.—From lake Timsah	13320·35 met. (14567·14 yds.)	.....	9329·45 met. (10202·63 yds.)	.....	.....
	Ditto ditto	.....	2016·50 met. (2205·26 yds.)	.....	.....	.....
237	Angle IX., 157° 12′ 08″ (141° 24′ 31″)	.....	.....	.....	3879·36 met. (4242·47 yds.)	10000 met. (10936 yds.)
	Ditto ditto	.....	2016·50 met. (2205·26 yds.)	.....	.....	.....
	Tenth main line. — Cill of Ferdanne	10848·70 met. (11864·14 yds.)	.....	6762·20 met. (7395·14 yds.)	.....	.....
	Ditto ditto	.....	2070·00 met. (2263·75 yds.)	.....	.....	.....
264	Angle X., 156° 45′ 00″ (140° 49′ 18″)	.....	.....	.....	4057·07 met. (4436·81 yds.)	10000 met. (10936 yds.)
	Ditto ditto	.....	2070·00 met. (2263·75 yds.)	.....	.....	.....
	Eleventh main line.—To the Mediterranean	44030·00 met. (48151·21 yds.)	.....	41430·00 met. (45307·84 yds.)	.....	.....
	The eleventh line passes 28·500 met. (17 miles 6½ fur.) westward of Pelusium.	147956·85	46610·80	100816·05	44215·82	.....

As regards cross-sections, they have been taken wherever the ground presented any undulations, and they have been extended, in some places, as far as 4,000 metres (4374·4 yds.) on each side of the Canal, so as to discover the points most favourable for excavation. It is by investigations of this nature that the most economical longitudinal section for the Canal has been arrived at. Although it has not been considered a necessary obligation to curtail expense, wherever it may be required for the perfect execution of the works, it is, nevertheless, of importance not to incur cost where it would be of little use, and it is by these considerations that we have been guided in our choice of the lines definitively adopted.

It will have been evident from the foregoing details that, for the most part, we have agreed with the Authors of the Project, and that, with the exception of the modification of the track through Lake Menzaleh, we have adopted their longitudinal and cross-sections, reducing only the dimensions of the Canal to proportions which appeared to us more suitable, and which had the advantage, moreover, of being less costly. The modification in the last portion of the line was a consequence of the change of position of the opening of the Canal into the Gulf of Pelusium; the recent soundings, which determined its adoption, not being previously in existence to lead the Authors of the project to a similar conclusion.

There would be little advantage in giving a detailed enumeration of all the cross-sections of the ground, and we have contented ourselves with simply giving the longitudinal section of the Canal. The plans annexed to this Report exhibit the section of the jetties both at Suez and Pelusium; and the statements in the several sections of this report will suffice to form a very clear conception of the general line of the Canal.

SECTION XVII.

CUBICAL MEASUREMENT.

THE cubic content of the various works to be executed in the construction of the Ship Canal, has been calculated by the Engineers of his Highness the Viceroy, to whom will be entrusted the execution, in accordance with the dimensions laid down in the descriptive portion of this Report, and conformably with the plans annexed.

The Earthworks have been divided into two classes:—

The first includes all the material that can be removed by manual labour.

The second the work which will have to be performed by dredging-machines.

In order to establish this division, the results of the borings executed throughout the Isthmus, (a table of which is annexed to the present report,) have served as a basis. All the earth situated below the level at which water was met with has been placed in the second category, but it is possible that a con-

siderable portion of this earth may be excavated without the assistance of dredging-machines. It has been deemed prudent, however, to include them in the most difficult portions of the work to be executed, in order that the actual expense may be less than the calculated amount.

In order to facilitate and simplify the calculations of the contents of the earthworks, without affecting the exactness of the definitive results taken in a mass, the ground has been supposed to be horizontal along the line of each cross-section. Each surface of the section has been calculated at intervals of 10 centimètres (3 ft. 9 in.) beginning at a depth of 1 mètre of cutting, and when the depth of the excavation did not correspond exactly to a multiple, the section approaching nearest has been taken.

In other places different methods have been had recourse to.

For the portion traversing the Bitter Lakes, commencing from Section No. 100 to 158, the ground being at one time lower, at another higher, than the bottom of the canal, a mean measurement has been taken equal to 1·55 mètres (1·69 yds.), and the amount of material to be removed has been calculated according to the section constructed on this basis.

The cubical contents of twenty-six dunes sand hills, not marked in the longitudinal section have been added, amounting to 241·511 cubic mètres (315·826 cubic yds.)

Lastly, among the earthworks for the canal, has been classed the excavation which will be requisite in order to construct a basin, 500 mètres (546·80 yds.) in length, between Port Saïd and Port Timsah.

The total cubical measurement of the earthworks for the canal itself amounts to 96,177,926 cubic mètres (125,800,727·208 cubic yds.)

As regards the Excavations to be executed for the construction of the jetties and for the inner basins, we have considered it proper to state them separately, as they are to be performed entirely by machinery and under conditions differing altogether from the dredging required for the canal. The total amount of stuff to be removed by dredging amounts as follows:—

For the harbour of Suez.....3,800,000 cubic mètres.
For the harbour of Timsah.... 900,000
For the harbour of Said.....3,600,000

8,300,000 (10,856,400 c. yds.)

At the harbour of Suez, and that of Saïd, a portion of the material will be carried out into the sea.

In order to ascertain, as nearly as possible, what portion of the excavations can be done by manual labour, the level at which water was found, in the boring operations, has been taken as a guide. The mean depth of this level was found to be 3·87 mètres (12 ft. 8·4 in.) above the water line of the Canal; the level was taken, therefore, at four mètres (13 ft. 1·5 in.), and the section has been constructed upon this round number. All that is above this level is set down as to be removed by manual labour, and all below will be excavated by dredging. By this method it has been found, that the portion which was to be removed by hand, formed a mass of 46,000,000 cubic

mètres (60,168,970·6 cubic yds.), that is, a little less than the total amount to be removed; and the portion to be dredged under water 50,177,926 cubic metres (65,633,786 cubic yds.) These figures represent the maximum amounts, as no account has been taken of the shortening of the distances produced by the curves occurring in portions of the line, and the calculations have been made on the length of the main lines as though the canal were to follow all the angles of the projected track.

SECTION XVIII.

ANALYSIS OF PRICES.

The determination of the Price of each description of labour is a matter of experience, and depends upon the localities where the works are executed. The Commission was, therefore, unable either to state what this should be, in each case, or to question the statements of others. It has consequently entrusted M. Mougel Bey, one of the Viceroy's Engineers, with the performance of this task, in consequence of the long experience acquired by him in the large dockyards of which he has had the management. The result of his labours has been adopted by the Commission and is subjoined to the Report.

It will be observed, that two different prices are fixed for the rubble-work required at Port Saïd. The Commission are of opinion that the jetties of this port should be commenced with the materials derived from the neighbouring islands and from the coast of Asia, until a direct and easy communication be established with Suez and the quarries of Attaka. This communication could scarcely be ready before the end of the fourth year, at which period all the works at Suez would be completed, and the entire produce of the quarries in working at that point might be then applied to the completion of the works of Port Saïd. It has been supposed that one half of the work would be executed with materials from external sources, and the other half with materials from Attaka.

The prices laid down in the Project of the Viceroy's Engineers have undergone still further modifications, but we shall not enter here into details which will be found fully stated in another part of the report. There is, however, one modification, of considerable importance, (to which we must allude. The Authors of the Project had estimated the cost of the carriage of materials at 3 centimes per ton per kilomètre. One of the most honourable and influential firms of Paris engaged in undertakings has since proposed to contract for the carriage at 1½ centimes instead of 3 centimes. The cost of carriage would thus be reduced to one-half, and this constitutes a very important saving.

In analysing the cost of the works, we must not overlook one essential point which characterises the whole of this special question. This is the Official Order *(Réglement)* concerning the Fellahs to be employed as labourers by the Universal

Suez Canal Company. As native workmen are to constitute at least four-fifths of the entire body of labourers employed in these works,—and if the Official Order be abided by, they will, no doubt, in reality compose nine-tenths of them,—it was important, in order to calculate the cost of manual labour, that the rate at which these workmen could be employed should be formally fixed. This necessity is met by the decree of the 20th of July, 1856.

In order to form a just notion of the bearing of this decree it will be requisite to refer to the Charter of Concession itself. This act contains the assurance, that the Universal Company will have at its disposal as many workmen, whatever the number may be, as will be required for the execution of the enterprise.

Article II. fixes, as we have just stated, the minimum proportion of native workmen who shall be constantly employed upon the works.

Article XXII. promises to the Company the loyal and unreserved concurrence of the Government and its officials. It places at the disposal of the Company the two principal Engineers of his Highness the Viceroy, upon whom will devolve with the direction of the works, the superintendence of the workmen, and the execution of the regulations relative to the general management.

The practical application and determination of the conditions and clauses attached to the act of concession thus became, as regarded the Company, the guarantee of their best interests, and the prompt and economical completion of the works. It was requisite to obtain the assurance that such a number of vigorous workmen, inured to the climate,

would never be wanting, as could always be spared from the labours of agriculture, without injury to the country, and that there would be a maximum rate of wages, upon which might be based the estimates of the expense which we are called upon definitively to settle.

Thanks to this decree, the Company will henceforward be assured of having always as many labourers as the works will require, without the necessity of those wholesale migrations of European workmen which have been alluded to as a physical difficulty and a political inconvenience.

The average rate of wages will be less by two-thirds than for similar undertakings in Europe; whilst the rate of payment to the Egyptian labourers will exceed by more than a third the average price they have hitherto received for their labour in their own country.

Independently of their wages in specie, healthy lodging and food are assured to the workmen. They will be, moreover, provided gratuitously, with medical assistance, in cases of illness, and during its continuance will receive a daily allowance equal to one-half of their pay.

These measures, which reflect the highest honour on the humanity of the Egyptian Government, will have the advantage, as respects the estimates of the works of the canal, of furnishing us with a precise and perfectly-fixed basis of calculation. They divest our estimates of two of the most usual sources of error in determining the cost of an extensive undertaking: failure of workmen and augmentation of the price of labour.

SECTION XIX.

ESTIMATE OF EXPENDITURE.

THE estimated cost of the works of every description for the construction of the Canal across the Isthmus of Suez, set forth in detail in the annexed tables, is classed under separate heads and according to the nature of the work. This analysis has been made, with the greatest care, by M. Mougel Bey, one of the Viceroy's Engineers. After arriving at the conviction, that there did not exist any omission, or error, in the calculations of M. Mougel Bey, the Commission have approved them. The Engineer in question has been many years resident in Egypt, and has the advantage of experience, having had the direction of important public works in this country for upwards of twenty years. This, as a guarantee that the estimates proposed by him would approximate, as nearly as possible, to the actual expenditure. It is, moreover, a fortunate coincidence, that he should be one of the Engineers entrusted with the execution and direction of the works of the Ship Canal.

By Name of Works.	DESCRIPTION OF WORKS. Particulars.	Quantity.	Price per Unit.	Product.	Cost of each Work.
			f. c.		
1° Canal between the two Seas.	Dry Earthwork	46,000,000 c. met. (60,168,970·6 c. yds.)	0 67	30,820,000 fr. (£1,232,400)	
	Ditto under water	50,177,926 c. met. (65,633,786 c. yds.)	1 00	50,177,926 (£2,007,117)	
	Stone pitchings for banks and banquettes	496,364 c. met. (649,254·6 c. yds)	8 00	3,970,912 (£158,836 9s. 7d.)	85,368,838 fr. (£3,414,753 10s. 0d.)
	Fixing dunes	.....	....	300,000 (£12,000)	
	Ferries	.....	....	100,000 (£4,000)	
2° Canal through the Wadee.	Works to be executed by the Viceroy by contract, on penalty, according to the estimates in the project	.....	....	.....	9,000,000 (£360,000)
3° Harbour of Said.	Landing place and temporary harbour	.....	....	850,000 (£34,000)	
	Dredging the harbour	c. m. 3,600,000	1 25	4,500,000 (£180,000)	
	Foundationsin rubbles	834,000	14 50	12,019,622 (£480,784 17s. 7d.)	
	Bed of concrete on foundation ..	39,935	18 84	552,700 (£22,108)	
	Rubble masonry	102,606	18 91	1,940,290 (£77,611 4s. 0d.)	21,059,075 (£842,363)
	Revetment in wrought stone ..	18,217	24 66	449,231 (£17,969 4s. 9d.)	
	Parapet on the western jetty ..	3,500	123 18	431,150 (£17,245 4s. 0d.)	
	Quays of the inner basin	800	395 14	316,112 (£12,644 9s. 7d.)	
4° Harbour of Timsah.	Dredging the harbour	900,000	1 22	1,125,000 (£45,000)	1,589,120 (£63,564 4s. 4d.)
	Quays	1,000	464 12	464,120 (£98,564 4s. 0d.	
5° Harbour of Suez.	Dredging the harbour and its approaches	3,800,000	1 25	4,7500,000 (£190,000)	
	Foundations in rubbles	221,503	6 25	1,384,393 (£55,375 14s. 4½d.)	
	Bed of concrete on foundations	24,870	13 84	344,200 (£13,768)	
	Rubble masonry	93,032	14 36	1,335,939 (£53,437 11s. 2½d.)	8,649,562 (£345,982 9s. 7d.)
	Revetment in wrought stone ..	18,391	19 71	362,486 (£14,499 8s. 9½d.)	
	Parapet on the western jetty ..	2,000	19 78	39,560 (£1,584 8s. 0d.)	
	Quays of the inner basin	800	395 14	432,984 (£17,319 9s. 6½d.)	
6° Miscellaneous Works.	Light-houses, harbour lights, beacons	.....	....	235,000 (£9,400)	
	Working stock for quarries, tools, &c.	.....	....	600,000 (£24,000)	2,355,000 (£93,400)
	Store-houses, buildings, hospitals	.....	....	1,500,000 (£60,000)	
	Total of works for constructing the canals	.....	....	.....	128,000,595 (£5,120,063 16s. 0d.)
7° Accessory Works.	Fixing the dams	.....	....	1,200,000 (£48,000)	
	Cultivation of granted lands ..	.....	....	8,000,000 (£320,000)	
	Electric telegraph	.....	....	150,000 (£6,000)	15,850,000 (£634,000)
	Steam towing stock	.....	....	3,000,000 (£120,000)	
	Careening and refitting dock ..	.....	....	3,500,000 (£160,000)	
	Total estimated expenditure	.....	....	.....	140,851,598 fr. (£5,754,367 6s.)

The estimated expenditure, (including 15,850,000 francs for accessory works of a nature calculated to augment the profits of the enterprise,) amounts therefore to.....fr.143,851,595

To this figure must be added, in order to determine the actual expenditure—	
1st. Expenses of administration, estimated at 2½ per cent. on the capital	3,578,164
2nd. A sum for omissions and casualties, estimated at about 10 per cent. of the expenditure, according to the estimates	14,570,241
Grand total of expenditure for the works ....fr.	162,000,000
or £6,480,000 sterling.	

In estimating the expenses of administration at 2½ per cent. of the capital, we have followed the usage adopted in Europe. If, on the one hand, the salaries of the higher grade of officials are higher in Egypt, on the other, those of the inferior servants and workmen are much less. We have, consequently, with the Authors of the Project, regarded these differences as compensating each other.

Fixing the amount for omissions and casualties, at 10 per cent. of the estimates, has, in our opinion, left a large margin for contingencies. The simplicity of the arrangements for executing the project renders it almost impossible that any important omission should have been made. A Canal to be excavated in a soil, the nature of which is thoroughly ascertained and which appears to be very favourable for the undertaking, the construction of jetties upon shores where the sea is never rough, constitute works which from their very character do not admit the possibility of any serious mistake.

The only portion of the works exhibiting a prospect of unforeseen contingencies—the Junction and Irrigation Canal—is to be executed by contract on penalties, for a fixed sum of 9,000,000 fr. by the Egyptian Government.

The grand Total of the expenses for the works of the Canal, therefore, and for all the accessory works connected therewith, amounts altogether to 162,000,000 fr. (£6,480,000). This leaves a difference, (as compared with the company's capital fixed at 200,000,000 fr. (£8,000,000), of 38,000,000 fr. (£1,520,000), which is thus appropriated:—

1. To the payment of five per cent. on the capital during the execution of the works.

2. To the formation of accessory establishments, destined to augment the profits of the company.

In order to calculate the amount of interest payable to the shareholders up to the period when the undertaking will return a profit, it is necessary to estimate the annual increase and expenditure for the duration of the works. These anticipations not admitting of more precise details than those given in the project, we may calculate roughly, that the payment of interest on paid-up capital, after deducting the revenue, will absorb about one-half of the available sum of 38,000,000 fr. (£1,520,000.)

This general estimate of the expenditure required for the execution of the project will, in all probability, not be exceeded; it is based upon the detailed estimates drawn up by M. Mougel Bey, and approved of by the Commission.

The estimates, appended to our report, are divided into nine chapters, under the following heads:—1st, Earthworks; 2nd, Rubble foundations in the sea; 3rd, Concrete masonry; 4th, Masonry of jetties; 5th, Parapets; 6th, Quay walls; 7th, Auxiliary junction and irrigation canal; 8th, Cultivation of granted land; 9th (and lastly,) Miscellaneous expenses—and under this general head are comprised, a first-class lighthouse; two harbour lights and two beacons; a careening dock at Timsah; a building yard; storehouses, buildings, hospitals, stables, &c.; a temporary landing-place and harbour at Saïd; an electric telegraph, with two wires, along the entire course of the Ship Canal; the working stock of the quarries, and the purchase of tools for the workmen; the stock for steam-towing with two chains, one for the up, the other for the down-stream, track, &c.

The cost of the earthworks is 91,372,926 francs (£3,654,917,) of itself constituting nearly two-thirds of the total expenditure.

The rubble foundations in the sea for the jetties of Suez and Saïd form the largest item of expenditure next to the the earthworks, and amount to nearly 17,000,000 francs (£680,000.)

Next follow the auxiliary canal and the cultivation of the granted land. These two items of expenditure are estimated at 9,000,000 francs (£360,000,) the first; and 9,600,000 francs (£384,000,) the second.

SECTION XX.

MATERIALS FOR THE CONSTRUCTION OF THE HARBOURS.

It has been shown by the analysis of the borings executed at various points of the Isthmus, that no hope could be entertained of obtaining either beds of rock, or detached blocks, along the course of the canal. The imperfectly-formed stones found at Scheik Ennedek, previously alluded to, are absolutely unavailable for any sea works. They could only be used for the pitching the banks.

The only natural source of material which the Engineers will find at hand is the mountain of Attaka, situated to the S.W. of Suez, and not far from the sea. This resource is of considerable extent, and must be largely made use of. There will not be any land carriage; barges will be loaded at a temporary landing-place and will convey the material wherever it may be required.

We are impressed with the belief, that after some further search and a more careful examination, Attaka will be found to yield stone capable of being used for the masonry of the crown and parapet. But, supposing the

quarries of Attaka should not yield the stone required, it is certainly to be obtained on the Arabian coast, at the other side of the roadstead, in the quarries of M'Salem, which have been long in work. These quarries are from 10 to 12 kilomètres (6 to 7½ miles) from the shore. The stone obtained from them is used for a variety of works at Suez. Even if the carriage was from a somewhat greater distance and more costly, it is certain that the stone thus obtained would be of good quality.

There is, therefore, no difficulty to be anticipated as to the means of construction of the harbour and jetties of Suez.

The materials derived from Attaka might also serve for the stone-pitching along that portion of the banks of the canal, about 10 kilomètres (5 miles) in length, between Suez and the Bitter Lakes, where this precaution would probably be requisite. The entire tract of ground traversed by the canal at this part of the Isthmus extends, as before said, to about 20 kilomètres (12½ miles). The subsoil throughout is clay, but this clay varies in compactness and the degree to which it is mixed with sand. Prudence, therefore, points out the necessity of protecting it with a stone pitching wherever any errosion, or undermining of the banks might be anticipated from the action of the current.

Were any other works necessary beyond the operation of dredging, either at the entrance of the canal into the Bitter Lakes, or for the point of its emergence therefrom, the materials furnished by the quarries of Attaka might again be usefully employed; for the water will be admitted as soon as possible and the carriage would be easy.

For the works of the port of Timsah, and more especially for those of Port Saïd, it would be impossible, at least at an early period, to think of obtaining materials from the quarries of Attaka, or of M'Salem. There would be no communication open, and it would be out of the question to wait until it were completed, for the commencement of the works of Port Saïd. As regards the works of the port of Timsah, use will be made as far as possible, of the Junction Canal, which will, in the second year, have reached Suez.

For Port Saïd recourse must be had to other means. The only course open is to seek the materials required in some of the neighbouring islands, where they are to be procured of the finest quality, within convenient reach of the sea and at little cost. We allude to the islands of Cyprus, Rhodes, Scarpanto, &c. The coast of Asia might offer similar resources. These islands are, it is true, situated at some little distance; but an operation of the kind, when imposed by the necessity of the case, is no extraordinary occurrence, nor one beyond the sphere of habitual practice. The jetty of Malamocco was constructed entirely of rough blocks brought from the quarries of Istria, at a distance of thirty leagues on the other side of the Adriatic. In Holland, every stone employed in the Helder and other sea works has to be brought all the way from Norway. In the particular case now engaging our attention, there would be less difficulty than may be imagined. The small blocks may be brought by ordinary merchant vessels. The large blocks would be transported by vessels of a special character, constructed on a system most favourable for the operation of loading and unloading the stone.

If it were not that the coast of the Gulf of Pelusium is

devoid of every material that might serve for the construction of the jetties, we should not have recourse to this expedient. But not only does it yield no stone proper for masonry, but even the rough material for rubble-work, or pebbles for concrete are equally absent. The soil consists entirely of the fine sand along the shore, or the muddy sediment accumulated from the alluvium of the Nile. It occurred to us, indeed, to employ the stone obtainable from Toura near Cairo, and that of Mohattan, which might be brought by the Damietta branch. But the insufficient depth and the variable condition of the *boghazes* would always render this resource very precarious and there should be no risk of an interruption to the works when once they are commenced.

We are, moreover, sensible of the high value which attaches to a means of execution, from the nature of which the construction of the Canal would be placed out of the reach of all chances of interference from external occurrences. No doubt it would be better to draw the materials from Egypt herself, and not to seek any assistance from without. There is no lack of them in the country, and it is well known what treasures of this description it contains. But the conveyance of these materials is rendered impossible during the season of low water, or at least the difficulties, as has been shown, are almost insurmountable. The Commission, therefore, cannot act otherwise than refer the whole matter to the Engineers, who will be charged with the direction of the works upon the ground. It recommends them, in a general manner, to take every advantage of local resources: of the Nile, such as it actually affords; of the Junction and Irrigation Canal, which will be shortly completed; and of the Grand Ship Canal itself, as by degrees the several por-

tions, being successively finished, become in any way available for the purposes in view. Men of skill, attentive to every circumstance of the case, will know how to derive advantage from all these resources, either simultaneously, or successively, as emergencies arise.

All that can be said here is, that the construction of the port of Saïd, although somewhat costly, is not of a nature to justify the fears which have been entertained. With still better reason, may we assert as much of the Inland Port of Timsah, to which materials will easily be brought, by the Junction Canal, so soon as it shall be completed. As regards this portion of the works, the case is evident beyond all doubt. But, in respect of Port Saïd, it would always be a source of apprehension, that if the materials were brought from Egypt, a number of transhipments would be necessary; whereas, drawing them from the Greek Archipelago, or the Adriatic coast, the whole carriage would be by water, and the conditions would be such as could be calculated beforehand.

SECTION XXI.

ESTIMATED COST FOR THE MAINTENANCE OF THE SHIP CANAL.

THE International Commission would not have considered its mission fully discharged, had it not sought to determine approximatively the cost for the maintenance of the Canal.

The cost for keeping up the Ship Canal may be classed under five heads:—1. The two Entrances; 2. The Canal, properly so called; 3. The Engineering works; 4. The Light-houses; 5. The Officials and Servants; 6. Miscellaneous expenses.

1.—*The Two Entrances.*

An attentive study of the movement to which the sand along the coast is subject, has proved that no fears need be entertained of the silting-up of the harbour of Saïd, and that this port would exist, under more favourable conditions than any other port hitherto created on the shores of the Mediter-

ranean, as for instance—Cette, Barcelona, Malamocco, &c. If, nevertheless, we admit, what is an almost impossible eventuality, viz., that its situation will be that of the worst of these ports, Cette: it will be found that the total quantity of silt to be removed annually will amount to 100,000 cubic mètres (109,363 yds.), equivalent to an expenditure of 100,000 fr. (£4,000) for the maintenance of the port of Saïd.

As regards the port of Suez, the stability of the seashore here can be called in question by none; and it is very probable that this stability, the natural consequence of the character of the shore, and the regimen of the sea in the roadstead, will not be appreciably altered by the establishment of jetties. To make allowances for unforeseen emergencies, the maximum amount of silting may be taken at 30,000 mètres (32,808 yds.), corresponding to an expenditure of 30,000 fr. (£1,200).

Thus, the total expenditure under this head will be under 130,000 fr. (£5,200).

2.—The Canal, properly so-called.

We have here only to deal with the question of maintaining the Canal at its proper depth, repairing banks, towing-paths, &c.

If we take the canals of France as a point of comparison, and from among these select the canal from the Marne to the Rhine, as that which absorbs the largest amount for maintenance, we shall find the cost of maintenance to be at the rate of 1 fr. per mètre (8¾d. per yd.) of its length; and of

this, the proportion for earthworks and dredging is only 0·20 fr. If we consider the cost of maintenance to be in proportion to the section, the cost for keeping up the Ship Canal will be at the rate of 5 fr. 33c. per mètre of its length (3s. 11$\frac{3}{4}$d. per yd.)

If we pass from the canals of France to those of Lombardy, which exist under conditions more nearly approaching those of the Ship Canal, being perfectly open and presenting falls of as much as 1·50 mètres per kilomètre (1 in 1,000) as is observed in the *Naviglio Grande*, the section of which, moreover, is at certain points 200 mètres (218·73 yds.), and on a general average 40 mètres (43·745 yds.), it will be seen that the expenditure for maintenance is 0·48 fr. per running mètre (4d. per yd.); and, comparing the sections of these canals to that of the Ship Canal, it will be found that the cost of maintenance for the latter would be 5·95 fr. per mètre in length (4s. 4d. per yd.).

Finally, if we examine what has occurred for the last fourteen years with respect to the Ship Canal in North Holland, which is 78$\frac{1}{2}$ kilomètres in length (48 miles), we shall find that the annual expense, amounting on an average to 391,221 f. 60 c. (£15,648 17 3$\frac{1}{4}$) is distributed as follows:—

1. Engineering Works	149,904 f. 30 c. (£5,936 3s. 5$\frac{1}{4}$d.)
2. Dredging, Earthworks, &c ..	196,564 f. 20 c. (£7,862 11s. 4$\frac{1}{4}$d.)
3. Salaries, Wages, &c	44,753 f. 10 c. (£1,790 2s. 5$\frac{3}{4}$d.)
	391,221,60 fr.

The maintenance of the Canal itself, therefore, amounts altogether to 2·50 per running mètre (1s. 9¾d. per yard).

The breadth of this work, which is preserved with the greatest care, is 37·67 mètres (41·19 yds.), and its depth below the water-line 6 mètres (6·56 yds.) By comparing the sections with each other, the figure arrived at for the cost of maintenance, is 7·08 f. per mètre. As this is the highest figure of any yielded by a comparison with other canals, it is the one we have adopted; and as the length of the Ship Canal is 147 kilomètres 956 mètres from the commencement of the Suez jetty to that of the other at Saïd, the annual expenditure to be set down under the second head is 1,047,528 fr. (£41,901 2s. 4¾d.)

3.—*Engineering Works.*

Rubble Foundations for the Jetties.—Jetties constructed with artificial blocks of from 10 to 15 cubic mètres (13·08 to 19·62 cubic yards) have never, up to the present time, required any expense for their maintenance, as blocks of this kind are not moved by the force of the waves. As regards jetties constructed with rough natural blocks, nothing very precise is known, as to the expenditure required for their maintenance. The cost for maintenance depends on the dimensions and weight of the materials used in the structure, as well as the force of the waves.

Thus, at Algiers, before the works were constructed with artificial blocks, the footing of the dykes forming the quays had to be filled in afresh every year; whereas, at Bar-

celona, the jetties made of natural blocks of 1 mètre cube to 1·50 (1·308 to 1·962 cubic yards) only require fresh filling at rare intervals, and to an inconsiderable extent.

It is believed that sufficient allowance will be made for all eventualities, taking into consideration the conditions under which the jetties will be established, if the fresh filling in required annually be estimated at 1 mètre cube (1·308 cubic yards) for 5 mètres in length of the Saïd jetty, and 10 mètres of the one at Suez. The quantity to be supplied yearly, therefore, will be—

At Port Saïd, 1,200 cubic mètres of blocks, at 10·80 fr.	12,960 fr.
At Suez, 380 cubic mètres	2,375
	15,335 fr.
	(£613 8s.)

As regards the masonry of the jetties, it may be asserted, that in the climate of Egypt works of masonry will continue unaltered for an indefinite period. A few slight repairs only will be required from time to time. Setting down the annual cost at 1·50 fr. per mètre of the jetty's length, will provide a wide margin for all required repairs. For this item, therefore, the expenditure will be ..... 24,500 fr. (£980)

The quay walls require very little repairing, for they are constantly under water,

and an incrustation is formed on their surface of small shell-fish, which preserves them for an indefinite period. It is, however, expedient to set them down among the items in the costs for maintenance, and 1 fr. per mètre in length has been considered sufficient, making in all .	2,800 fr. (£112)
As regards the pavements of the quays, the cost of maintenance will vary, according to the traffic, the form and weight of the vehicles used, and the materials of which the pavement is composed. Taking 3 50 per mètre in length as the average figure for the annual cost will bring us, we believe, near the truth. This would amount annually to	44,100fr. (£1,764)
	86,735 fr.
Total Expenditure for Works of Art.....(£3,469 8s.)	

4.—*Light Houses.*

For a lighthouse of the first class, the annual expenditure reckoned for maintenance is about 3,000 fr. (£120); and for a harbour-light 700 fr. (£28).

As there will be two lighthouses of the first class, and four harbour-lights, the expenditure under this head will be.....	8,000 fr. (£352)

Staff.

As a basis to estimate the cost of the staff of servants and officials, the example of the North Holland Canal has been taken, which canal is very efficiently maintained under circumstances very nearly similar to those of the Suez Canal. The expenditure for the staff amounts to 44,753 fr. (£1,790 2s.) for a length of 78,500 mètres, making 0·57 (5d.) per metre. The Ship Canal being 147,956 mètres in length, the expenditure under this head would be .. 84,385 fr. (£3,373 8s.)

Miscellaneous Expenses.

Among the miscellaneous expenses must be set down—

1. The Canal of Communication, the cost of which is reckoned at 1 fr. per running mètre, the same as that of the canal from the Marne to the Rhine, making..... 128,600 fr. (£5,140 8s.)

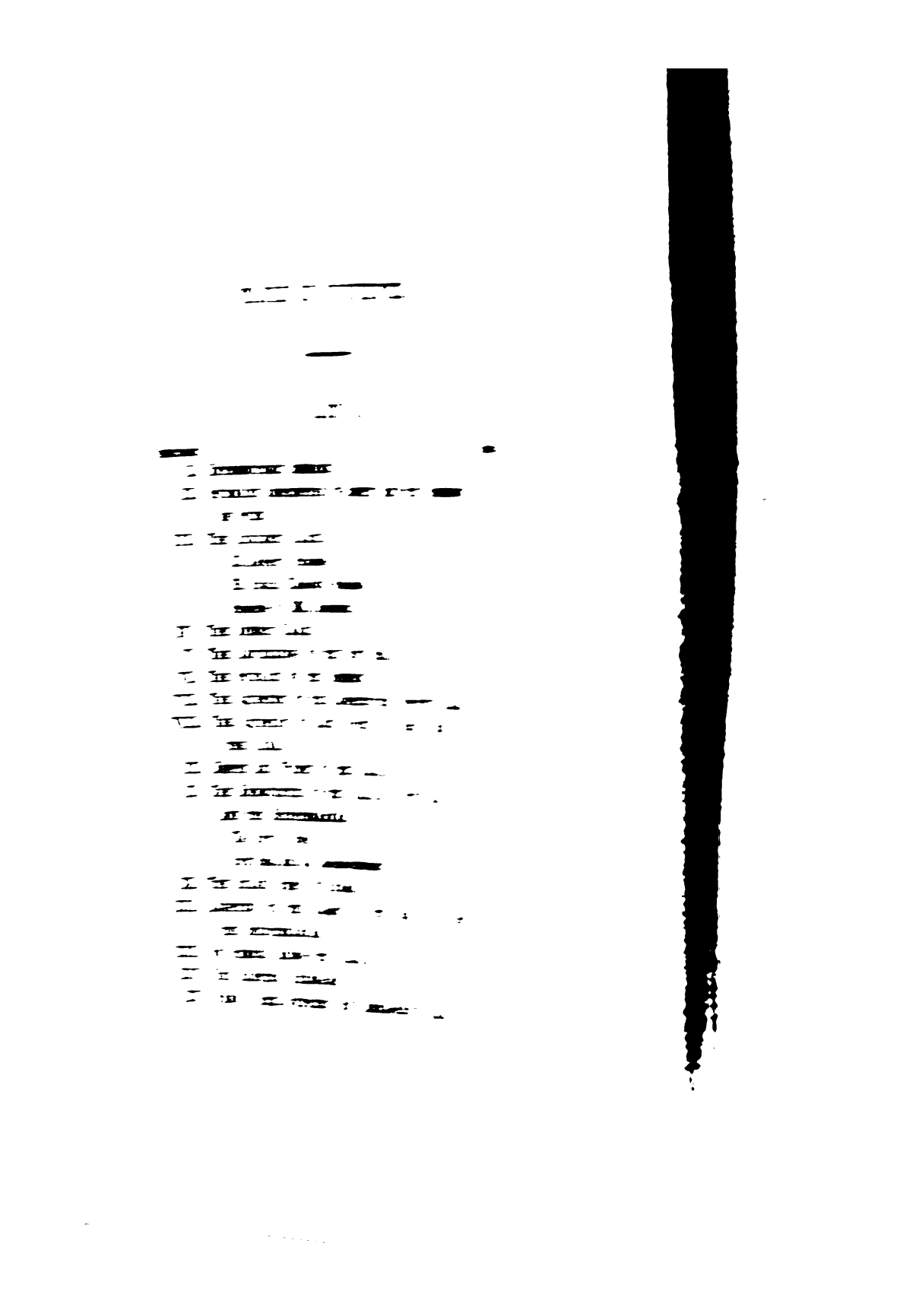
2. The Water-Course for Irrigation, set down at 0·50 fr., in all ..... 43,500 fr. (£1,740)

3. The Careening Dock ..... 10,000 fr. (£400)

4. The Building-Yards and Workshops....	6,000 fr. (£240)
5. The Dockyard, Storehouses, Hospitals, Stables, &c.	25,000 fr. (£1,000)
	213,100 fr. (£8,520 8s.)

Recapitulation.

1. The two Entrances of the Canal	180,000 fr. (£5,200)
2. Dredging and Earthworks	1,047,528fr. (£41,901 2s. 4¾d.)
3. Engineering Works	86,735 fr. (£3,469 8s.)
4. Lighthouses and Beacons	8,800 fr. (£352)
5. Staff.....	84,335 fr. (£3,373 8s.)
6. Miscellaneous Expenses	213,100 fr. (£8,524)
	1,570,498 fr. (£62,819 18s. 4d.)



SECTION XXII.

CONCLUSION.

After pursuing all the foregoing investigations, we have now arrived at the conclusion of our task, and it only remains to terminate, by a general Summary, this long Report, which brings to a close the Mission confided to us by His Highness, Mohammed Saïd, Viceroy of Egypt, and M. Ferd. de Lesseps, Concessionary of the Suez Canal.

In determining the several conditions of the Grand Ship Canal, destined to unite the Mediterranean and the Red Sea, and to yield a passage to the commerce of the world, we were exposed to commit one of two faults—either doing too much, or too little: attempting a gigantic enterprise, or restricting ourselves to works of inadequate extent. One or the other of these errors would have been equally fatal, and it was incumbent on us never to lose sight, either of the general interests of civilization, which this project must advance to an immense degree, or of the private interests of the Company proposing to undertake its execution.

We are led to believe, after mature examination, that we have remained within the proper limits, and have not exceeded a true statement of matters, either in one sense or the other. A canal of from 80 to 100 mètres in width, with a depth of eight mètres,—not provided with locks at either entrance,—not liable to any dangerous currents—extending to a length of about 30 leagues—with vast and secure harbours at its two extremities—certain of preservation and easy of maintenance—opening into two roadsteads of indefinite extent: a Canal, such as this, appears to us to satisfy all the actual exigencies of navigation. It is even probable that for a long period, it will be found adequate to all the requirements of the future. On the other hand, there is nothing in the conditions we have laid down which would militate against any further extension being given to the undertaking, should such be deemed necessary.

In immediate connexion with the Canal, we have not neglected the subject of its approaches. Access to it will be facilitated to the utmost by such lighting of the coast as that we have demanded.

The two seas, united by the Suez Canal, will present no species of danger or difficulty likely to be seriously formidable in the eyes of mariners. As regards one of these seas, the only objection is that it has been but little navigated, and therefore is little known; the other is in a similar predicament as respects that particular portion of its shores at which the canal will open.

We are, therefore, assured, as far as concerns the navigation taking its course annually round the Cape of Good Hope, that it may adopt with great advantage, and in full

security, the new path offered to it by the Suez Canal, and which is already marked out in the line of postal communication England has established.

As regards the interests of the Company, which it was our duty to protect with equal solicitude, we believe that these, in like manner, have not been lost sight of. The works proposed by us are not characterized by any peculiar features, which withdraw them from the ordinary sphere of engineering art and science, nor are they exposed to any dangerous eventuality. All the elements composing them are known, and have been studied in the minutest details, as is testified by the length of this report. The Grand Ship Canal joining the two seas will far from absorb the sum which, with a wise prudence, has been fixed as the Company's capital. Our colleagues had, in submitting the summary of the results of their investigation to the Viceroy, assured him, that the total expenditure would not exceed 200,000,000 fr. (£8,000,000). Our calculations, rendered as exact as possible, demonstrate clearly that they were not mistaken. The total expenditure will amount to only 162,000,0000 fr. (£6,480,000), leaving 38,000,000 fr. (£1,520,000), at least as an available fund, either for the payment of interest during the execution of the works, or for ulterior improvements.

The carrying a Canal across the Isthmus of Suez is, therefore, a work of far greater importance, from the objects it is to effect, than from the outlay with which it will be attended. It is evident, that an expenditure of 200,000,000 fr. (£8,000,000), devoted to the execution of this canal, would be within the resources of any one of the wealthy nations now accomplishing, under our eyes, so many marvellous railway

enterprises, infinitely more difficult and costly. That sum will amount to a mere trifle, divided among the nations directly interested in the undertaking—viz., England, France, Austria, Holland, Piedmont, Italy, Prussia, Spain, Portugal, the Ottoman Empire, and the United States. We are absolved, however, from dealing with mere suppositions: the readiness with which capital has been offered even without a public appeal on the part of the Concessionary, proves satisfactorily that it will not be found wanting to the execution of an enterprise, presenting itself to the civilised world with so high a claim to their estimation derived from its character of utility and perfect practicability.

For our own parts, we, whose aid in advancing the enterprise has been purely of a scientific nature, believe ourselves to be fully justified in declaring, as did our colleagues when visiting the locality, that the execution of the canal joining the two seas, under the conditions to which we restrict it, is not a matter of difficulty and that its success can admit of no doubt. In our opinion, therefore —viewing it in the light in which we are bound to receive it —no serious obstacles oppose a junction between the two seas. The work will be one of some years' duration, but there are not any insurmountable natural impediments.

Our pleasure has been so much the livelier in contributing, within the measure to which we were called upon to assist, to the realization of this work of civilization and humanity, that the most significant and weighty facts are daily coming to light, proving, more and more clearly, how urgent is the need for this work, in the present state of the world's international relations. Immense changes are taking place in naval affairs from the progressive results of

the application of mechanics and new modes of construction. Steam has almost entirely superseded the use of sails in vessels of war; the screw is, from this day forth, the principal motive-power employed in them, being at once the safest and the most regular in its action. This transformation is now almost entirely complete in the navy of England; it will shortly be equally so in the navies of other nations, who will not consent to continue without so valuable an advantage, and thus voluntarily submit to a dangerous inferiority.

The transformation now, as we have said, almost complete as respects the navy, cannot be long retarded in the merchant service, although it will necessarily be slower. The interests involved in commercial speculations are those of individuals—or, at least, they are divided among a number of separate parties: there is no supreme and common authority to bring about simultaneously, and within a brief period, such costly changes, however indispensable. Only by degrees, therefore, will the mercantile navy carry out this transformation in the mechanical means it employs, which, in their present state, must be considered imperfect, and unfit to be retained, except for the more restricted requirements of coast trading. Already on all sides radical modifications are being effected, and no private company called upon to establish a new service, or to repair the stock of one formerly existing, fails to introduce steam power. Even the least costly merchandise, if in great demand, is conveyed in screw-ships. We may cite for example, coal, which, along the coasts of England, is now rarely otherwise carried. The freight in these cases, taking time into consideration, is below what would be demanded in sailing vessels. For more distant voyages, the changes are no less considerable; and there are companies in Liverpool

whose charges for freight in screw-ships to Constantinople are the same as those which sailing vessels are forced to ask.

The naval officers, forming part of this Commission, are unanimous in the adoption of these views; they believe that even before the canal joining the two seas can be completed, the mercantile navy will have undergone a complete revolution, which is now being accomplished piecemeal. We are equally persuaded that these anticipations are well founded.

May it not therefore be asked:—Will the commercial shipping, at present passing round the Cape of Good Hope, continue to perform a voyage twice the length, through dangerous though well-known seas, when the possibility is presented of striking out a route half the length, better known, as regards a portion of its extent, than the former, and much less dangerous as regards the whole passage? The only objection of any weight, it has been possible to urge against the Suez route, is, that sailing ships would meet considerable difficulties in the Straits of Gibraltar, and of Bab-el-Mandeb. These difficulties, be it said, are greatly exaggerated. But under the hypothesis we have assumed, and which is already nearly half converted into a reality, all these objections naturally fall to the ground. Where sails would be found to fail, the screw from this time forth, without the least trouble, can be made to overcome all obstacles, be they the currents of Gibraltar, or the monsoons of Bab-el-Mandeb. The mails travel very regularly, backwards and forwards, between Southampton and Alexandria in thirteen days, and are but little longer on the journey from Suez to Bombay. Nay more! clippers with the auxiliary screw, have performed the run from Melbourne to Liverpool in

two months. They would have required still less time had they come by the Red Sea, the Suez Canal being open. The British Admiralty has already so far testified its appreciation of the advantages of this route that, in a recent contract for the conveyance of the Australian mails, the leading obligation imposed on the Contractors was, that the mails should be taken by Suez, as are those for India and China. There is this to be noted, however, that the Admiralty refused to bind itself for more than five years, not without some anticipation, it may fairly be surmised, that, even at the end of so brief a term, changes of such importance might be brought about, as that the prospect of them, even now, rendered it desirable not to alienate its entire freedom of action.

But, even setting aside this hypothesis, which, as we have said, is nevertheless daily growing into a fact, it is evident, that for sailing vessels, as they at present exist, it would be an incalculable advantage to be able to shorten their voyage by one-half, even though they should occasionally require the assistance of steam-tugs,—of which an adequate supply could be ensured, as at the Straits of Gibralter in 1847,—and have to take advantage of the favourable season in the Indian seas as respects the monsoons.

From all the above considerations it follows, that the opening of the Suez Canal, already rendered necessary by the present and progressive development of the relations between Europe and Asia, will daily become more and more important.

The time is not distant when the mercantile navy, in its transformed state for the performance of long voyages, will demand the opening of this new route, attended with such

great facilities and so much profit. The Suez Canal will not hasten this transformation, but, on the contrary, a large body of screw shipping sprung into existence will necessitate the removal of this barrier. It is not possible that so insignificant an obstacle as this tract of perfectly level ground, scarcely 30 leagues across, should continue much longer a hindrance to so certain and profitable a result.

It is not our province to judge what motives may have retarded the execution of a work of this character. But we believe we are only echoing the universal opinion in saying that all delay is to be deplored when once a well-matured opinion on the subject has been formed. Our object has been to enlighten, in so far as in us lay, the Governments and Nations of the world; with all confidence, we submit to them the final results of our inquiry. May our labours hasten the moment when all impediments, other than those existing in the actual nature of things, shall be removed and when the artificial Bosphorus at Suez may be thrown open to the navies of all nations.

F. W. CONRAD,
President of the International Commission.

LIEUSSOU,
CHARLES MANBY, } *Secretaries.*

Paris, December, 1856.

REGULATIONS FOR THE FELLAH WORKMEN.

(*Extract from "l'Isthme de Suez," Journal de l'Union des Deux Mers.* No. 5, 25th August, 1856.)

THE Act of Concession for the Suez Ship Canal contains the implicit assurance that the Universal Company should have at its disposal all the workmen necessary for the execution of the enterprise.

Article II. sets forth, that in all cases four-fifths at least of the workmen employed shall be Egyptians.

Article XXII. promises to the Company the loyal and entire concurrence of the Government and of its functionaries. It attaches to the Company the two chief Engineers of his Highness the Viceroy, who shall be charged with the direction of the works, with the supervision of the workmen, and with the execution of the regulations respecting the mode of conducting the works. The practical application of the principle, and the determination of the conditions and clauses attached to its execution, constitute one of the most essential points of the Company's interests, and the most solid guarantee for the prompt and economical achievement of the works.

It was important that the Commission should be assured

that during the progress of the works a sufficient number of vigorous workmen, inured to the climate and whose services were always available, should not be wanting, and that a maximum rate of wages should be fixed to ensure the regularity and *bonâ fide* character of the estimates, which the Engineers of the International Commission are about to present in full detail. It was also necessary that, for the complete security of the works, a great concentration of orderly, disciplined, and healthy workmen, adequate to all emergencies, and such as to present reciprocal advantages to the interests of labour on one side, and of capital on the other, should be obtained. It is with this object that, on the 20th July last, his Highness Mohammed Saïd kindly placed in my hands the decree, to which I have deemed it proper to give publicity, in order to inspire confidence beforehand in all interests, and to answer many objections which have been made as to the facility of execution of the canal joining the two seas. Thanks to this act, the Company will be henceforth certain of having at its disposal the number of workmen which the engineers in chief may judge necessary, without causing those wholesale transmigrations of European workmen to which we should never have been compelled to have recourse, but in which certain faultfinders have fancied a practical difficulty and a political inconvenience would be found.

In the interest of the Company, the tariff of wages will be two-thirds less than that of similar enterprises in Europe.

In the interest of the workpeople, it will exceed by more than one-third the average rate of the daily pay which they have, up to the present time, obtained in Egypt.

Independently of wages in specie, healthy abodes and rations are guaranteed to the workmen, as well as an asylum and gratuitous medical attendance, in case of sickness or injury.

Moreover, the sick or the wounded will receive a daily allowance equivalent to half their pay. We believe it is the first time this measure of foresight and humanity has been systematically introduced into workshops, even in Europe.

The solicitude shown in this important circumstance by his Highness the Viceroy, in favour of the labouring classes, hitherto too much neglected in the East, and the guarantees exacted to protect and succour them, will present to the minds of those who know the ancient manners of the East, the highest proof of the progress, which, under the generous impulses of his Highness Mohammed Saïd, Egypt is making towards the ideas and civilization of the West. This prince, as well versed in the tenets of his religion as in the sciences of Europe, knows that the Mussulman law is not opposed to progress; and he often says that it is bad Governments and the antiquated manners and customs of the East, rather than the laws, which require reform.

Indeed, that book which has proclaimed charity as the principal rule of life, and where it is said that the best man is he who does the most good to his kind, will never stand up as an obstacle to the application of measures which the most advanced civilization may counsel.

FERD. DE LESSEPS.

REGULATION.

We, Mohammed Saïd Pasha, Viceroy of Egypt, being desirous to ensure the Execution of the Works of the Suez

Ship Canal, to provide for the good Treatment of the Egyptian Workmen who will be employed on them, and to watch over at the same time the interests of the Landowners, Cultivators, and Contractors of the country, have established, in concert with M. Ferdinand de Lesseps, as president and founder of the Universal Company of the said Canal, the following Arrangements:—

Art. I. The Workmen to be employed on the works of the Company shall be supplied by the Egyptian Government, according to the demands of the Chief Engineers, and in proportion as they are needed.

Art. II. The Pay allotted to the Workmen shall be fixed according to the average rate paid for private works, viz., two piastres and a-half to three piastres per day, exclusive of rations, which shall be delivered in kind by the Company to the value of one piastre.

Labourers under twelve years of age will only receive one piastre and a full ration.

Rations in kind will be distributed daily, or every two or three days, in advance; and in cases when it can be ascertained that workmen requesting to provide their own food are in a position to do so, the ration shall be given to them in money.

The Pay in Money will be given out every week. The Company, however, during the first month, will only pay half wages until it has accumulated a reserve fund of a fortnight's pay; after which the full amount will be paid to the workmen.

The charge of providing an abundant supply of drinking water for all the wants of the workpeople will rest upon the Company.

Art. III. The Task imposed upon the Workmen shall not exceed that which has been fixed by the Administration of

Bridges and Highways in Egypt, and has been adopted in the great works of canalisation executed of late years.

The Number of Workmen employed shall be fixed with special regard to the periods of agricultural labour.

Art. IV. The Regulations for the order of the building-yards shall be carried out by the Officers and Agents of the Government, under the orders and according to the instructions of the Chief Engineers, conformably to a special regulation which shall receive our approbation.

Art. V. Those workmen who shall fail to complete their task must submit to a diminution of pay, which shall not be less than a third, and proportioned to the deficiency of the work allotted. Deserters shall forfeit, by the very fact, the fortnight's pay in reserve; the amount whereof shall be paid into the chest of the hospital mentioned in the next article. Men causing a disturbance in the yards shall also forfeit the fortnight's reserve pay. They shall, besides, be subject to a fine, which shall be paid to the hospital fund.

Art. VI. The Company shall be bound to find shelter for the workpeople, either under tents, in sheds, or suitable houses. It shall support at its own expense an hospital and ambulances, with all the material and staff requisite to treat the sick.

Art. VII. The Expenses for the Conveyance of the Workmen engaged, and of their families, from the place of departure to their arrival at the yards, shall be at the charge of the Company.

Each sick workman shall receive at the hospital or in the ambulances, besides the care which his state may require, an allowance of a piastre and a-half during all the time that he is incapacitated from working.

Art. VIII. Skilled workmen, such as masons, carpenters, stone-cutters, smiths, &c., shall receive the pay which the

Government usually allows them on its works, besides rations, or the value thereof.

Art. IX. When soldiers on active service shall be employed on the works, the Company shall disburse for each of them, superior pay, common pay, or nominally as expenses for keep, a sum equal to the pay of the civil workmen.

Art. X. All the waggons necessary for the conveyance of earth and materials, as well as the powder for blasting purposes, shall be furnished by the Government to the Company at cost price, provided the demand for them be made at least three months beforehand.

Art. XI. Our Engineers, Linant Bey and Mougel Bey, whom we place at the disposal of the Company for the direction and conduct of the works, will have the general supervision of the workmen, and will come to an understanding with the delegated managing director of the Company to remove any difficulties which may arise in the execution of the present decree.

Done at Alexandria, the 20th July, 1856.

(L. S.)

(Seal of his Highness the Viceroy.)

(Translated from the Turkish.)

HYDROGRAPHIC OBSERVATIONS

IN THE

BAY OF PELUSIUM.

Reports of Captain Philigret from his Station in the Gulf of Pelusium.

FIRST REPORT.

Off Pelusium, Jan. 9, 1857.

According to the instructions received on the 7th inst., I, accompanied by M. Darnaud, Engineer, and by my mate, repaired on board the corvette of his Highness the Viceroy of Egypt, whose Captain had made all preparations for leaving the harbour.

At noon we were taken in tow by the *Frez Djahad* steam-frigate. We were towed all night, and in the morning were off Damietta, where we found four merchant ships in their moorings in from five to six fathoms of water. To all appearance they were taking in cargo.

We proceeded up the Gulf of Pelusium in from five to six fathoms of water, and it was here we found out the advantage of the presence of Mr. Darnaud, because he is well acquainted with the coast. This officer, who has frequently sailed in these waters, piloted us until we sighted the tower of Dibeh, which was built during the French expedition. Two hours

later we sighted the tower of Gemileh. We were now deep in the Gulf of Pelusium, and it was a great satisfaction to me to find ourselves East and West with the tower of Dibeh, where we were sheltered from the winds, which, from their violence, are most to be feared in these waters.

I shall talk at greater length of this coast as soon as I shall have improved my acquaintance with it.

We went on in six fathoms of water, and at about five miles from the beach.

At 3 p.m. we dropped our anchor in six fathoms, and as soon as I have made out all the land-marks placed along the coast by the Engineers of the International Commission, in my next Report I shall send an exact statement of the whereabouts of my moorings. But I can tell you at present that the corvette is riding on her anchor at the spot prescribed by the International Commission, two cables'-lengths seaward from the extremity of the jetty projected for Port Saïd.

In obedience to my instructions I shall make exact entries of the prevailing winds, and the condition of the sea and the beach, and, in short, of all points of interest in the Bay of Pelusium; and I intend doing my best to send you at least every fortnight an extract from my journal.

SECOND REPORT.

Off Pelusium, January 20, 1857

On the 9th instant I had the honor to inform you of my arrival here.

I now hasten to send you a Second Report containing extracts from my Journal, in which I mention all points of

interest concerning the Bay of Pelusium and these coasts generally, which have not, up to the present time, been much frequented by sea-faring men.

On the evening of the 8th inst., when M. Darnaud had gone on board the steam frigate, and was just about to leave us for Alexandria, he thought he recognized some of the landmarks he had placed on the coast a year ago. He hailed us and told me to get under weigh and drop our anchor two miles further East. I told him that the sun was setting, and that the crew were about clearing the corvette fore and aft, and that I would change my position early next morning.

I wished to reconnoitre the coast, because I expected to find a certain land-mark with M. Darnaud's initials, which would have enabled me to have at once determined on my position.

I went on shore and found the beach very practicable. Unfortunately the land-marks erected by the Engineers of the International Commission had been destroyed by rains and by the crews of fishing smacks, and I had some difficulty in finding the spots where the signals had been placed. The boards with the letters and initials had been taken away. However, I was determined upon having an exact description of my moorings, and I sent M. Meusnié, my mate, with two sailors and a 50 metre measure, to the tower of Oum Fareg.

M. Meusnié reached the tower late at night and came back in the morning, reporting that he had measured the distance 16,800 metres from East to West.

I found that M. Darnaud was right, and that we were too far to the Eastward, and I ordered M. Meusnié to go on measuring the beach to 18,500 metres distance, which distance indicates the projected Port Saïd as marked in the map I received from Mougel Bey.

We rigged a flagstaff on this spot and anchored the

corvette to the South of this staff in six fathoms of water and two cables' length seaward from the projected jetty.

I cannot yet speak of the prevailing winds and currents, and must put this off to the end of my winter station, when I shall give you a general summary of this interesting portion of my mission.

On the night, from the 13th to the 14th January, we had a violent squall from the E.N.E.; it was borne with ease by the corvette, which kept her position and did not in any way drag her anchor. This is chiefly owing to the circumstance that the bottom of the Bay consists of fine sand, the best anchoring ground known to sailors.

As for the sea, I have told you already that any ship anchoring beyond the point of Dibeh is perfectly sheltered from the E. and N.E. winds. Hence the corvette was not disturbed by any waves, and lay as tranquilly as if she had been in dock. This is a precious advantage, and if I am to believe the fishermen who tell me that the most violent storms come from the E. or N.E., I may assume that the Bay being sheltered from the most violent winds, very little is to be apprehended from winds coming from another direction.

The beach has throughout been practicable, and I have been constantly able to communicate with the shore—except on the 13th, when the spray prevented my sending the small and very open boats of the corvette—while I am convinced that with whale-boats I could have gone on shore with the greatest ease.

I am now about to commence the reconstruction of the land-marks along the beach, and intend making them large enough to last for some time.

THIRD REPORT.

Off Pelusium, Jan. 31st, 1857.

I TAKE advantage of an opportunity of sending letters to Damietta to send you this third Report, extracted, like the preceding one, from my journal.

I have already told you that I devoted myself to the resetting of the Landmarks. I have now to announce to you that they are all completed, and on a very large scale too. The marks I have made are small towers of five feet high, to six feet basis, which can be seen from ten miles out at sea, and which will be very useful in case further hydrographic observations are to be made.

I have made them with small paths leading up to their tops and they command a fine view of Lake Menzaleh. From the tower in the centre of the litoral belt we see, on a clear day, the tower of Oum Fareg to the East, and that of Gemileh to the West,—on either side a distance of sixteen miles.

During the last ten days we have had calms and northerly winds, and the steadiness of the corvette convinces me that merchant ships might safely anchor in the Bay.

I have remarked that the horizon was frequently clouded, and that the clouds drifted rapidly in a southerly direction, while the sea and the beach were rather rough, without, however, preventing communications with the shore; for, I repeat it, we lay as tranquilly as possible.

These observations induce me to believe that the majority of the north winds do not enter the Bay, and that, with the exception of an occasional squall, no apprehensions need be entertained from anything blowing from that direction.

The winds changed to E.N.E., and you know against such winds the Bay is perfectly sheltered. Two ships

on their way to Alexandria or Damietta have anchored close to the corvette.

The currents are almost imperceptible in the Gulf, and what little there is seems generally to follow the direction of the wind. But in calm weather a very slight current runs in a north-easterly direction.

FOURTH REPORT.

Bay of Pelusium, February 10.

NOTHING of interest occurred on the 1st and 2nd February. The sky was cloudy, and a strong breeze was blowing from the E.N.E. The currents were imperceptible, and the beach such as to enable us with ease to communicate with the shore.

On the 3rd we had a terrible gale—first from the S.E., then from the N.E., and finally from the S.

I shall devote this Report to the various phases of this hurricane. I mean to make this description with the greatest care, and shall be happy, if sooner or later, it turns out to be of some use to mariners that visit these waters.

The gale commenced at 2 a.m. on the 3rd, when the wind shifted suddenly from the E.N.E. to the E.: a stiff fair breeze with a southerly leaning, but no indications of anything unusual. It had been cloudy, but now it got dark and foggy. The barometer showed a slight fall.

This lasted until 10 a.m., when the wind shifted to the S.E. and rapidly increased in force, still with a southerly leaning. The weather looked very dirty, and the barometer had still a downward tendency.

At 2 p.m. the wind blew direct from the South, and it soon attained the proportions of a real tempest. This continued till 4 p.m., when it shifted to the East, and at 10 p.m. to the E.N.E., from which direction it blew a hurricane.

The hurricane continued all night and slackened only at 4 p.m., when, sinking by degrees, but still blowing from the E.N.E., it changed into a strong gale.

I have been gratified to find, by measuring the distance from the corvette to the shore, that, thanks to the tranquillity of our position and the soundness of our moorings, the corvette, in spite of the violence of the wind, did not change her position or drag her anchor.

This fact may be considered as decisive, for I am persuaded that it is impossible to meet with a worse hurricane. I do not therefore hesitate to declare that the Bay of Pelusium offers very good moorings with the winds from the E., S., and N.E., and that the anchors hold in all weathers.

The N. and N.E. winds, more especially, are those which interest me, and to which I devote my attention.

FIFTH REPORT.

Bay of Pelusium, Feb. 20.

Since the last hurricane the winds have been from the S., E., and N.E. We have had several gales from those directions. They were less violent than the gale of the 3rd February, but still they were strong enough still further to convince me of the soundness of my moorings.

The sea, which must be violently agitated beyond Damietta Point, and which, impelled by the gale which has lasted

almost a fortnight, must roll up enormous waves, does not enter into the Bay. Only when the wind shifts to the S.E., and when it therefore blows straight from the land, it causes a good deal of breakers on the beach.

I have now to tell you of another violent gale from the North, on the 17th, 18th and 19th February.

I have already told you that the winds from the N. and N.E. are the only ones which need be feared in the Gulf of Pelusium, and these last days put me in a position to repeat my assertion.

On the morning of the 17th, the weather was dull and rainy, the wind came from the E.S.E., from which direction had blown for several days past.

At 9 p.m. I was struck by the dark and heavy appearance of the northern sky, where there was an accumulation of clouds, and an occasional flash of lightning The E.S.E. wind died away gradually, and by 10 p.m. it was quite calm. This doubtful calm lasted but a very short time. A strong breeze sprung then up from the E.N.E., and this breeze rose to such a height, that by 1 a.m. it blew a gale.

Nevertheless the clouds were rapidly drifting towards the south, while the lightning still flashed in the north: large waves commenced rushing into the Bay, and I remarked that the wind had a tendency to shift to the north.

At 5 a.m. on the 18th, the wind did indeed shift to the N.E., and at 9 a.m. we had a furious gale coming from due N.

This gale must have been terrible out at sea, for although my observations enable me to state that there is frequently a northerly wind out, while the bay is perfectly calm, still, on this occasion these limits were passed, and the tempest was strongly felt in the Bay of Pelusium.

The corvette bore it bravely, and without any strain; she

On the 4th, a Greek brig, running in an easterly direction, traversed the whole length of the bay.

On the evening of the 8th of March, clouds rose from the E.N.E., with a gale from that direction. The gale lasted some hours. After this the weather cleared up, and continued most favourable up to the present moment.

EIGHTH REPORT.

Alexandria, March 20.

SIR.—I have already announced to you that the return of a milder season leaves me no remarkable facts to communicate.

In the last few days we have had variable breezes, which freshened during the day and went down with the sun, so that the nights were perfectly calm. These breezes were most frequently from the W.N.W., or the E.N.E.

On the 16th, however, the wind blew steadily from the W.N.W., but this breeze, too, fell at sunset, and the night was calm.

NINTH REPORT.

Off Pelusium, March 20.

I HASTEN to send you the specimens of the bottom of the Bay, which you demanded, and I beg to add to them an explanation as to the various depths from which these specimens were brought up.

No. 1. Grey sand mixed with mud from the anchorage of the corvette at ten mètres fifty centimètres water.

No. 2. Black mud from farther out at a depth of from ten to twelve mètres.

The depth of ten mètres may be considered as the limits of the muddy and the commencement of the sandy bottom. At this depth the sand gets free from the mud and is the purer the nearer we approach the shore, until at last it is quite pure, as may be seen in specimen.

No. 3, taken from the beach. I have remarked that, by mixing a specimen of the bottom at $10\frac{1}{2}$ mètres with a specimen of sand from the beach, I obtain exactly the quality of stuff to be found at a depth of from five to six mètres.

I have nearly terminated my general account of the Bay of Dibeh. It will contain a summary of all the observations and remarks I made on my station.

TO M. FERDINAND DE LESSEPS.

Sir,—Having been informed of your near arrival here, I take the liberty to write and inform you of the good hold of my corvette in the roads of Suez, in spite of the violent tempests we had in February last.

There is nothing extraordinary in this, if you consider the excellent quality of the bottom, and the great advantage of being perfectly sheltered during the E.N.E. winds, which blow almost constantly, and which bring the worst gales in these waters. The captains who pass along the coasts of Algiers would be very glad of such moorings as are to be found in the Bay of Dibeh, where there is plenty of room with a regular slope, and the best bottom possible, instead of the exposed roads we find on the coasts of our African colony, and which to a foul bottom add this further disadvantage that they are entirely open to the north winds which constantly blow gales during the winter.

I have had for a time the command of the steamer *L'Hirondelle*, and I carried the Tunis despatches in September, 1854. On that voyage we had a squall from the N. which was a Storm, and this squall has enabled me to make a comparison with the Bay in which I am now stationed, and to appreciate to their full value the previous condition of the Bay of Dibeh, as well as all the guarantees it offers to navigation.

I have also frequently been in the Gulf of Bengal, and I make bold to say that it is not an easy matter to find a more dangerous offing than that Gulf during the furious hurricanes which blow in the S.E. monsoons.

In these hurricanes the entrance to the Hooghly is as

bad as can be, and I may almost say it is impracticable, and captains of great experience who have grown old and grey in those waters, have told me over and over again that a good many ships go down to the bottom. Next, when you are up in the branch of the Ganges, you are not yet out of danger; and if a ship with her cargo in her but touches any where, she is sure to be swept down by the current. I could quote recent examples of this sort of thing happening frequently.

With all these disadvantages, which do not exist in the Bay of Pelusium, Calcutta has a deal of commerce, and a very large number of ships go there continually.

My observations in the Roads of Dibeh, of which I have the honor to submit to you a general summary at the end of my winter station, enable me to say, that when the light-houses are established and with good pilots, and when all precautionary measures which so important a project demands are taken, the vessels that would make the Canal will find much assistance in the guarantees offered to them by the capital conditions of the Bay of Dibeh.

I have been looking out for work for the soldiers on board the corvette, to prevent their falling into idle habits.

I have put them to repair the landmarks placed by the gentlemen of the International Commission; and I have got them to build a big tower, of a basis of 22 metres, to a height of 20 metres. There is a spiral road to the top from whence there is a very fine view.

No men can work harder than these gallant fellows and this work, great as it was, has been done in a very short time. This landmark is exactly on the spot where the Eastern jetty of the Canal is to start from, according to the map which was given me by the Chief Engineer. It may become an excellent point of observation, especially before

the time when there will be plenty, and on so flat a coast, it may be of good service to ships in the offing, who, when they once know it, will shape their course by it.

This piece of masonry, which I would beg permission to call *Saïd's Tower*, is quite completed and we are preparing to give it a sort of house-warming. We have covered it with flags, and the corvette waits but for sunrise to fire a salute of 21 guns.

I remain, Sir,
Your obedient humble Servant,

B. PHILIGRET.

Gulf of Pelusium,
March 10th, 1857.

THE END.